

# EXHIBIT F

**UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF KANSAS**

IN RE URETHANE  
ANTITRUST LITIGATION

MDL 04-1616 (JWL/JPO)

THIS DOCUMENT RELATES TO:  
POLYETHER POLYOL CASES

Civil Action Nos. 08-2617, 09-2026, 10-2077

**RULE 26 DISCLOSURE OF LESLIE M. MARX, PH.D.**

**September 20, 2013**

## Table of contents

I. Qualifications .....	1
II. Assignment .....	3
III. Materials relied upon .....	4
IV. Summary of opinions .....	5
V. The Raiff Report's industry background (section 5) .....	6
V.A. Products (Raiff Report section 5.1) .....	6
V.B. Demand (Raiff Report section 5.2) .....	6
V.C. Production process overview (Raiff Report section 5.3) .....	6
V.D. Suppliers (Raiff Report section 5.4) .....	7
V.E. Plaintiff overview (Raiff Report section 5.5) .....	7
V.F. Changes in the industry over time (Raiff Report section 5.6) .....	7
V.G. Evidence that prices were influenced by collusive conduct during 1994 through 1998 (Raiff Report section 5.7) .....	7
V.H. The relationship between prices in the United States, Europe, and elsewhere (Raiff Report section 5.8) .....	9
VI. The Raiff Report's econometric analysis (Raiff Report section 6) .....	10
VI.A. Introduction (Raiff Report section 6.1) .....	10
VI.B. Selection of the benchmark period (Raiff Report section 6.2) .....	10
VI.C. Supply and demand variables (Raiff Report section 6.3) .....	11
VI.D. Defendant sales data considerations (Raiff Report section 6.4) .....	11
VI.E. Benchmark product category models (Raiff Report section 6.5) .....	12
VI.F. Transaction-level models (Raiff Report section 6.6) .....	12
VI.G. Calculation of damages (Raiff Report section 6.7) .....	12
VII. The Raiff Reply Report .....	13
VII.A. Introduction (Reply Report section 2.1) .....	13
VII.B. Polyether polyol product prices are consistent with the existence of a conspiracy (Reply Report section 2.2) .....	13
VII.C. Price dispersion is consistent with the existence of a conspiracy (Reply Report section 2.3) .....	14
VII.D. Supply and demand conditions during the allegation period are consistent with the existence of a conspiracy (Reply Report section 2.4) .....	14
VII.E. Customer switching and changes in the purchasing mix are consistent with the existence of a conspiracy (Reply Report section 2.5) .....	15
VII.F. Alleged strategic differences among Defendants are consistent with the existence of a conspiracy (Reply Report section 2.6) .....	15
VII.G. Dr. Raiff's econometric model reflects widely recognized and well-established best practices (Reply Report section 3.1) .....	16
VII.H. Dr. Raiff's usage of weighted median prices is standard (Reply Report section 3.2) .....	16
VII.I. Dr. Raiff's model relies upon appropriate supply and demand variables (Reply Report section 3.3) .....	17
VII.J. Dr. Raiff's model uses an appropriate estimation technique (Reply Report section 3.4) .....	17
VII.K. Dr. Ugone's modifications to Dr. Raiff's model are inappropriate (Reply Report section 3.5) .....	18

VII.K.1. Dr. Ugone's usage of disaggregated data results in a less reliable and comprehensive alternative to Dr. Raiff's econometric model (Reply Report section 3.5.1).....	18
VII.K.2. Dr. Ugone's transaction-level models corroborate Dr. Raiff's results (Reply Report section 3.5.2) .....	19
VII.K.3. The 2004 data belong in the benchmark period (Reply Report section 3.5.3) .....	19
VII.L. Dr. Ugone inappropriately interprets Dr. Raiff's coefficient estimates and their statistical significance (Reply Report section 3.6) .....	21
VII.M. Dr. Ugone failed to properly test the predictive performance of Dr. Raiff's model (Reply Report section 3.7) .....	21
VII.N. Dr. Raiff's overcharges measure the impact of Defendants' conspiracy on prices (Reply Report section 3.8) .....	23
VII.N.1. Dr. Ugone incorrectly calculated the confidence intervals he reported (Reply Report section 3.8.1) .....	24
VII.N.2. Confidence intervals and hypothesis testing (Reply Report section 3.8.2) .....	25
VII.N.3. Dr. Ugone wrongly claims that Dr. Raiff's model yields overcharges that are contrary to Direct Action Plaintiffs' allegations (Reply Report section 3.8.3) .....	31
VII.O. Dr. Raiff's overcharges are plausible and sustainable (Reply Report section 3.9).....	31
VII.O.1. Dr. Ugone's opinion is predicated on the wrong measure of profitability (Reply Report section 3.9.1) .....	32
VII.O.2. A more appropriate measure shows that Dr. Ugone's opinion is wrong (Reply Report section 3.9.2) .....	33
VII.O.3. Dr. Ugone's assertions are contradicted by his own analysis and are inconsistent with industry facts (Reply Report section 3.9.3) .....	33
VII.O.4. Dr. Ugone's profitability analysis ignores the overlap between polyether polyol products and other products (Reply Report section 3.9.4) .....	34
VII.O.5. Contrary to Dr. Ugone's claim, the pattern of Dr. Raiff's overcharges is reasonable (Reply Report section 3.9.5) .....	34
VII.P. Dr. Ugone's remaining criticisms do not change Dr. Raiff's opinions (Reply Report section 4).....	35
VII.P.1. Dr. Ugone's dummy variable models are unreliable (Reply Report section 4.2) .....	35
VII.P.2. Dr. Raiff has no reason to revise the Defendants' data that he relied upon (Reply Report section 4.3) .....	36
Appendix A. Additional figures .....	A-1
Appendix B. Curriculum vitae.....	B-1
Appendix C. Additional materials relied upon.....	C-1

## List of figures

Figure 1: Distribution of aggregate overcharges at 95% confidence for benchmark TDI .....	28
Figure 2: Distribution of aggregate overcharges at 95% confidence for benchmark MDI .....	29
Figure 3: Distribution of aggregate overcharges at 95% confidence for benchmark polyols .....	30
Figure 4: Benchmark product models .....	A-1
Figure 5: Actual and predicted prices for TDI 80/20.....	A-3
Figure 6: Actual and predicted prices for polymeric MDI.....	A-4
Figure 7: Actual and predicted prices for CFS polyols .....	A-5

## I. Qualifications

- (1) I am the Robert A. Bandeen Professor of Business Administration at the Fuqua School of Business at Duke University. In addition, I am a Partner at Bates White Economic Consulting (“Bates White”), a professional services firm that performs economic and statistical analysis in a variety of industries and forums. I specialize in microeconomics, particularly the fields of industrial organization and applied game theory, with a research focus on collusion, auctions and procurements. I received my Ph.D. in Economics from Northwestern University, and my B.S. in Mathematics from Duke University, where I graduated summa cum laude and was the valedictorian.
- (2) Prior to joining the faculty at the Fuqua School of Business in 2002, I was an Associate Professor of Economics and Management at the W.E. Simon Graduate School of Business Administration at the University of Rochester. I spent 2005–2006 as the Chief Economist for the Federal Communications Commission. I have taught graduate-level (i.e., Ph.D.) courses in game theory and industrial organization, and I have taught courses to M.B.A. students on managerial decision analysis, managerial economics, managerial game theory, and environmental economics.
- (3) Throughout my career, I have pursued a research program focusing on auctions, procurement, cartels and collusive behavior. My research incorporates my training in economic theory and econometrics. I have authored papers in many areas relevant to antitrust analysis, including papers examining the conduct of the Vitamins cartel, papers related to collusion at auctions, and papers on coordinated effects related to merger analysis. These and other of my professional papers have been published in peer-reviewed publications such as *Journal of Political Economy*, *American Economic Review*, *Quarterly Journal of Economics*, *Journal of Economic Theory*, and *Games and Economic Behavior*. I have received funding from the National Science Foundation and an Emerging Scholar Program Grant from the American Compensation Association.
- (4) In pursuit of my research program, I have used both theory and empirical data. I have studied data in a variety of contexts including bidding on oil and gas, FCC spectrum licenses, and U.S. Forest Service timber. I have studied financial data related to NASDAQ initial public offerings and bank performance. I have used econometrics to study issues such as pricing during and after the *Vitamins* conspiracy, the structure of executive compensation, and relationships between stock prices, spreads, and volumes.
- (5) Over the past four years, I have not provided testimony at trial. I did submit expert reports and testified at depositions concerning damages on behalf of a group of direct action plaintiffs in *In Re TFT-LCD (Flat Panel) Antitrust Litigation*, Master File No. M07-1827 SI, MDL No. 1827, (N.D.Ca.) in 2011 and 2012. I also provided deposition testimony in *Oxford Health Plans v Liberty Surplus*

*Insurance Corp.*, C.A. No. 03C-04-268 (WCC) in Delaware Superior Court in 2004. Further, I submitted a written expert report in *Emerson Electric Co. v. Le Carbone Lorraine, S.A.*, Case No. CV-6042 (D.N.J. June 2009), a Sherman Act case arising out of the carbon brushes antitrust litigation, which settled without my giving a deposition. In addition, I have provided consulting support on numerous plaintiff and defense antitrust matters, and I have extensive experience employing econometric tools similar to those used in this case. Additional information about my professional experience, including publications and affiliations, can be found on my curriculum vitae, attached as Appendix B.

- (6) Bates White is compensated at a rate of \$750 per hour for my work in this matter. My compensation is in no way contingent on the outcome of this matter.

## II. Assignment

- (7) I have been engaged by Counsel for the eleven Direct Action Plaintiffs (“Plaintiffs”) in this litigation. Another economic expert, Dr. Matthew E. Raiff, previously submitted expert reports and offered expert testimony in this matter. Dr. Raiff opined that Plaintiffs were overcharged as a result of a conspiracy among suppliers of toluene di-isocyanate (TDI), methylene diphenyl di-isocyanate (MDI) and various forms of polyether polyols (collectively “polyether polyol products”), and estimated Plaintiffs’ overcharges. I know Dr. Raiff and respect his work and professional credentials. Dr. Raiff and I were both partners at Bates White and we have collaborated on writing projects. I have been informed that Dr. Raiff will not be available to testify at trial.
- (8) Counsel for Plaintiffs asked me to do the following:

Please evaluate Dr. Raiff’s reports and testimony in this case, based on your independent review, to determine whether you can sponsor and defend Dr. Raiff’s methodologies, opinions, and conclusions at trial. Please address and evaluate only the subject matter and theories addressed by Dr. Raiff, and the criticisms of Dr. Raiff’s work by other experts in this matter. Upon completing your review and assessment of Dr. Raiff’s work, please provide in your own words an opinion as to the integrity and soundness of Dr. Raiff’s damages analysis, and the stated criticisms of Dr. Raiff’s analysis by Dow and its experts in this matter.

Counsel for Plaintiffs also instructed me that I am not to develop my own models or methodologies. I understand that the scope of my opinions is limited by a court order.<sup>1</sup>

---

<sup>1</sup> Memorandum and Order, Document Number 2974, August 13, 2013: “the Court grants plaintiffs’ request and orders that Dr. Marx, the new expert, will not be permitted to develop her own models or methodologies, but must endorse and defend Dr. Raiff’s opinions.”



### III. Materials relied upon

- (9) I had unfettered access to the materials that Dr. Raiff relied upon in this case. I was assisted in my review by senior members of Dr. Raiff's support team.
- (10) I reviewed expert reports submitted in this matter by Dr. Raiff,<sup>2</sup> Dr. Keith R. Ugone,<sup>3</sup> Dr. Kenneth G. Elzinga,<sup>4</sup> and Dr. James T. McClave,<sup>5</sup> the materials referenced in those reports, and back-up materials accompanying those reports. I reviewed deposition testimony by these experts and materials cited in their depositions. I also reviewed the briefs filed in support of and opposition to Dow's *Daubert* motion<sup>6</sup> and the transcript of the oral argument on the *Daubert* motion.<sup>7</sup> I and/or members of my team also reviewed additional materials listed in Appendix C.<sup>8</sup>
- (11) In the course of performing an independent review, I also relied upon my own training, experience, and expertise.

---

<sup>2</sup> Revised Expert Report of Matthew E. Raiff, Ph.D. May 13, 2011 (Raiff Report); Revised Reply Report of Matthew E. Raiff, Ph.D., July 13, 2012 (Reply Report).

<sup>3</sup> Rebuttal Expert Report of Keith R. Ugone, Ph.D. Responding to the Expert Report of Dr. Raiff, March 23, 2012 (Ugone Report).

<sup>4</sup> Economic Expert Report of Professor Kenneth G. Elzinga, March 23, 2012 (Elzinga Report).

<sup>5</sup> Expert Report of Dr. James T. McClave, April 15, 2011 (McClave Report).

<sup>6</sup> Dow's Memorandum in Support of Motion to Exclude the Expert Opinion of Opt-Out Plaintiffs' Damages Expert Dr. Matthew Raiff, Aug. 17, 2012; Direct Action Plaintiffs' Opposition to The Dow Chemical Company's Motion to Exclude the Expert Opinion of Opt-Out Plaintiffs' Damages Expert Dr. Matthew E. Raiff, Oct. 5, 2012; The Dow Chemical Company's Reply in Support of Motion to Exclude the Expert Opinion of Opt-Out Plaintiffs' Damages Expert Dr. Raiff, Nov. 6, 2012.

<sup>7</sup> Transcript of Proceedings before Honorable John W. Lungstrum, vols. 1–2, Nov. 19, 2012.

<sup>8</sup> Appendix C is intended to comply with the Stipulated Order on Experts' Discovery, Nov. 21, 2006.

## IV. Summary of opinions

- (12) I have performed an independent evaluation of Dr. Raiff's reports and testimony in this case. Based upon my review, experience, and training, in my opinion Dr. Raiff performed a sound, professional, and reliable analysis of overcharges to Plaintiffs. I am readily able to sponsor and defend Dr. Raiff's methodologies, opinions, and conclusions at trial.
- (13) Dr. Raiff employed a type of "prediction equation" to estimate overcharges. This is a well-accepted statistical method. Using reliable data and well-accepted regression techniques, Dr. Raiff developed an econometric model that provides reliable estimates of the impact of the alleged conspiracy on prices paid by Plaintiffs for TDI, MDI and polyether polyols (collectively, "polyether polyol products"). Dr. Raiff's model accounts for supply and demand factors that influence prices of polyether polyol products, and establishes that these factors fail to fully account for the movement of prices during the time of the alleged conspiracy.
- (14) Dr. Raiff's econometric model establishes that (with few exceptions) Plaintiffs paid higher prices during the alleged conspiracy period than they would have paid absent the alleged conspiracy. Dr. Raiff provides reliable estimates of the overcharges that were paid by Plaintiffs. I have considered criticisms of Dr. Raiff's analysis made by Dow and its experts, and Dr. Raiff's responses to these criticisms. The criticisms do not cause me to change my opinion that Dr. Raiff's estimates of overcharges are reliable.
- (15) The remainder of this expert report is organized in the following manner. Sections V and VI address the Raiff Report. Section VII addresses the Raiff Reply Report and criticisms of Dr. Raiff's analysis made by Dow and its experts.

## **V. The Raiff Report's industry background (section 5)**

- (16) Plaintiffs' counsel asked Dr. Raiff to determine whether and, if so, to what extent Plaintiffs were overcharged as a result of the alleged conspiracy.<sup>9</sup> The Raiff Report describes the data and methodologies employed by Dr. Raiff, the resulting overcharge estimates, and the bases for his opinions that his overcharge estimates are reliable and reflect widely recognized and well-established best practices. In this section, I present the results of my independent evaluation of the material presented in and described by the industry background section of the Raiff Report (Raiff Report section 5).<sup>10</sup>

### **V.A. Products (Raiff Report section 5.1)**

- (17) Paragraphs 35–87 of the Raiff Report provide background on the various products at issue, including TDI, MDI, and polyols, and describe U.S. sales by Defendants. Based upon my review, experience, and training, I conclude that Dr. Raiff's discussion is reasonable and supported by the record.

### **V.B. Demand (Raiff Report section 5.2)**

- (18) Paragraphs 88–102 of the Raiff Report describe the overall usage of TDI, MDI, and polyols, their end uses, and consumption by industry from 1992–2008.<sup>11</sup> Based upon my review, experience, and training, I conclude that Dr. Raiff's discussion is reasonable and supported by the record.

### **V.C. Production process overview (Raiff Report section 5.3)**

- (19) Paragraphs 103–117 of the Raiff Report describe the manufacturing processes for TDI, MDI, and polyols, and paragraphs 118–120 describe the obstacles confronting new entrants in the markets for TDI, MDI, and polyols. Based upon my review, experience, and training, I conclude that Dr. Raiff's discussion is reasonable and supported by the record.

---

<sup>9</sup> Raiff Report para. 1; Reply Report para. 1.

<sup>10</sup> The Raiff Report provides, in its sections 1–4, an executive summary, qualifications, a scope of charge, and materials relied upon. I have reviewed these sections, but as they are irrelevant to my charge or generally duplicate material discussed elsewhere in the Raiff Report or the Reply Report, I do not discuss these sections in further detail.

<sup>11</sup> Imports and exports of TDI, MDI, and polyols are also described in these paragraphs.

## **V.D. Suppliers (Raiff Report section 5.4)**

- (20) Paragraphs 121–156 of the Raiff Report summarize information about suppliers of TDI, MDI, and polyols, including data regarding capacity shares of producers between 1992 and 2008, and sales by Defendants between 1994 and 2003. Based upon my review, experience, and training, I conclude that Dr. Raiff's discussion is reasonable and supported by the record.

## **V.E. Plaintiff overview (Raiff Report section 5.5)**

- (21) Paragraphs 157–179 of the Raiff Report summarize information about Plaintiffs and their purchases. In addition, Appendix C to the Raiff Report describes Plaintiffs' procurement procedures and agreements with their suppliers. Based upon my review, experience, and training, I conclude that Dr. Raiff's discussion in these paragraphs and Appendix C is reasonable and supported by the record.

## **V.F. Changes in the industry over time (Raiff Report section 5.6)**

- (22) At paragraph 180 of the Raiff Report, Dr. Raiff wrote that "economic theory teaches that the structure and organization of an industry affect the relationship between prices and demand and supply variables and that they also affect the ability of a conspiracy to elevate prices." Based upon my review, experience, and training, I agree with Dr. Raiff's statement.
- (23) Paragraphs 181–194 of the Raiff Report discuss two developments that in Dr. Raiff's opinion had important structural ramifications for the industry, namely the closing of TDI plants and exit of two of five suppliers in 2005, and Hurricanes Katrina and Rita. Based upon my review, experience, and training, I conclude that Dr. Raiff's discussion is reasonable and supported by the record.

## **V.G. Evidence that prices were influenced by collusive conduct during 1994 through 1998 (Raiff Report section 5.7)**

- (24) In paragraph 195 of the Raiff Report, Dr. Raiff cautions that in constructing an econometric model, "the use of data from a time period when a conspiracy was in effect can cause a model to underestimate the impact of the conspiracy on price."<sup>12</sup> Based upon my review, experience, and training, Dr. Raiff's statement is reasonable, supported by the record, and consistent with well-accepted econometric practices.

---

<sup>12</sup> This point is also made in para. 235 of the Raiff Report.

- (25) Dr. Raiff was asked to calculate overcharges for two time periods—the alleged “conspiracy period” from January 1994 through December 2003 and the “class period” from 1999 through 2003.<sup>13</sup> To estimate overcharges for the shorter class period, Dr. Raiff sought to determine whether the 1994 through 1998 time period was tainted by conspiratorial conduct because, if it was, that time period should not be included in the benchmark period. Dr. Raiff “directed [his] staff to compile information and evidence, favorable and unfavorable, regarding the existence of a potential conspiracy during [1994 through 1998] that could have affected prices of polyether polyol products.”<sup>14</sup>
- (26) Paragraphs 196–213 of the Raiff Report explain the basis for Dr. Raiff’s conclusion that “it is not appropriate to include data from 1994 through 1998 in the benchmark period” for his class period model.<sup>15</sup> Paragraphs 196–200 (section 5.7.1) of the Raiff Report (and paragraph 13 of the Reply Report) explain why the structure of the markets for TDI, MDI, and polyols was conducive to effective collusion. Paragraphs 201–206 (section 5.7.2) of the Raiff Report summarize evidence that “defendants’ high-level executives in Europe and North America, with responsibility for the marketing and sale of polyether polyol products, frequently met and communicated with one another,” and “participated in meetings and communications during 1994 to 1998 (and, in many cases, during 1999 to 2003) that involved the discussion and coordination of urethanes prices charged to customers and the restriction of capacity.”<sup>16, 17</sup> Paragraph 202 of the Raiff Report summarizes information provided by outside counsel for Bayer, who conducted an internal investigation of Bayer’s involvement in the alleged conspiracy.<sup>18</sup> Paragraphs 207–213 (section 5.7.3) of the Raiff Report describe evidence that “BASF and Bayer organized their global urethanes businesses so as to

---

<sup>13</sup> Raiff Report at app. B.

<sup>14</sup> Raiff Report at para. 195. For purposes of estimating overcharges for the conspiracy period (i.e., 1994–2003), Dr. Raiff was instructed by counsel to assume that a conspiracy was in effect during 1994–1998.

<sup>15</sup> Raiff Report at para. 195.

<sup>16</sup> Raiff Report at para. 201. Some of the individuals that allegedly engaged in anticompetitive conduct had pricing authority over TDI, MDI, and polyols. For example, BASF’s President of Polyurethanes, Jean-Pierre Dhanis, had significant influence and control of BASF’s prices for TDI, MDI, and polyols. Raiff Report at para. 208. In the 1990s, Bayer employed a global strategic marketing director, Reinhard Clausius. Raiff Report at para. 199, 202. Similarly, Dow employed a global vice president, David Fischer, with responsibility for TDI, MDI, and polyols. Raiff Report at para. 216. I confirmed my understanding in this regard by inspecting the record on which Dr. Raiff relied. *See, e.g.*, Fischer Dep. 38:15-21; Dhanis Dep. 14:23-15:23; Stern Dep. 29:4-7, 125:22-24; Long Dep. 30:16-22. Economic literature indicates that firms may be able to collude more effectively across multiple products than across the same set of products considered in isolation. B. Douglas B. Douglas and Michael D. Whinston, “Multimarket Contact and Collusive Behavior,” *RAND Journal of Economics* 21, no. 1 (1990): 1–26. This supports my view that Dr. Raiff’s opinion that the conspiracy affected all three products is reliable.

<sup>17</sup> With respect to para. 206(d) of the Raiff Report, the cited evidence does not show whether Dhanis and Clausius met on May 28, 1998, the day Dhanis paid for a conference room at the Radisson Hotel in Brussels while Clausius was staying there. Dhanis was BASF’s President of Polyurethanes. Raiff Report at paras. 205(a), 208. Clausius was Head of Strategic Global Marketing for Bayer AG. Raiff Report at para. 202(d).

<sup>18</sup> Dr. Raiff was examined at length about his discussions with outside counsel for Bayer. I have spoken with outside counsel for Bayer and confirmed the information provided in para. 202 of the Raiff Report.

afford their European executives a high degree of influence and control over the pricing of urethanes products in the United States.”<sup>19</sup>

- (27) Based on my review, experience, and training, Dr. Raiff considered and relied upon the type of evidence that economists routinely rely upon in determining the appropriate benchmark period for purposes of estimating overcharges in a price-fixing case. Based upon my review, experience, and training, I agree with Dr. Raiff's decision to exclude 1994–1998 from the benchmark period.

### **V.H. The relationship between prices in the United States, Europe, and elsewhere (Raiff Report section 5.8)**

- (28) Because some of the evidence on which Dr. Raiff relied in deciding to exclude 1994 to 1998 from the benchmark period involved conduct by defendants' European executives, Dr. Raiff examined whether prices of polyether polyol products in the United States were related to prices in Europe and elsewhere. Dr. Raiff concluded that “on balance there was such a relationship,” although “there is evidence pointing both ways.”<sup>20</sup> Paragraphs 214–227 of the Raiff Report describe evidence on which this conclusion rests, including testimony by Defendants' executives (section 5.8.1), Defendants' contemporaneous justifications for price increases (section 5.8.2), international trade flows in polyether polyol products (section 5.8.3), and international trade flows in raw materials for polyether polyol products (section 5.8.4). Based upon my review (including paragraphs 207–213 of the Raiff Report), experience and training, I conclude that Dr. Raiff's conclusion is reasonable and supported by the record.

---

<sup>19</sup> Raiff Report at para. 207.

<sup>20</sup> Raiff Report at para. 214.

## **VI. The Raiff Report's econometric analysis (Raiff Report section 6)**

- (29) In this section, I present the results of my independent evaluation of the material presented in and described by the econometric analysis section of the Raiff Report (Raiff Report section 6).

### **VI.A. Introduction (Raiff Report section 6.1)**

- (30) Paragraphs 228–233 of the Raiff Report describe Dr. Raiff's "two-step" methodology for estimating Plaintiffs' damages. In the first step, Dr. Raiff developed an econometric model relating the prices of the "benchmark" product categories TDI 80/20, polymeric MDI, and CFS polyols to demand and supply factors.<sup>21</sup> In the second step, Dr. Raiff employed regression analysis to determine the relationship between the prices of each individual product and the prices of the corresponding benchmark product category. Dr. Raiff utilized the second-step model to calculate overcharges when "prices exhibited a systematic relationship over time to the prices of the associated benchmark product category."<sup>22</sup> "For products whose prices did not exhibit a systematic relationship to the prices of the associated benchmark category," Dr. Raiff "calculated overcharges based upon overcharges in comparable transactions."<sup>23</sup>
- (31) Based upon my review, experience, and training, Dr. Raiff's approach is well suited to the task of estimating damages in this case, widely accepted and used by economists, and accepted by federal courts.<sup>24</sup>

### **VI.B. Selection of the benchmark period (Raiff Report section 6.2)**

- (32) Paragraph 235 of the Raiff Report explains that "when a benchmark period is used to estimate what prices would have prevailed in the absence of a conspiracy, careful consideration should be given to selecting a benchmark period that is untainted by the conspiracy. Otherwise, the use of data from a time period when the conspiracy was in effect can cause the model to underestimate the impact of the conspiracy on price." As noted in paragraph (24), I agree with this statement.
- (33) Dr. Raiff had available data from January 1992 through December 2008. Paragraphs 236–239 of the Raiff Report explain that, for his conspiracy period analysis, Dr. Raiff excluded from the benchmark

---

<sup>21</sup> Raiff Report at paras. 229, 231.

<sup>22</sup> Raiff Report at para. 232.

<sup>23</sup> Raiff Report at para. 232.

<sup>24</sup> Raiff Report at paras. 230, 233.



period data from January 1994 through December 2003 because counsel instructed him to assume that an alleged conspiracy existed during this time. For his class period analysis, Dr. Raiff excluded data from January 1999 through December 2003 because he was instructed to assume that an alleged conspiracy existed during this time, and excluded data from January 1994 through December 1998 for the reasons described in sections 5.7 and 5.8 of the Raiff Report. Based upon my review, experience, and training, I agree with Dr. Raiff's decision to exclude 1994–2003 from his benchmark period.

- (34) Dr. Raiff explained that he chose to use data from both the “before” and “after” periods to estimate his econometric model.<sup>25</sup> Based upon my review, experience, and training, I agree with Dr. Raiff's decision to use both time periods in the benchmark period.

### **VI.C. Supply and demand variables (Raiff Report section 6.3)**

- (35) Paragraphs 240 and 245–248 (section 6.3.1) of the Raiff Report summarize the supply and demand variables accounted for in Dr. Raiff's econometric model. Paragraphs 249–265 of the Raiff Report describe variables employed by Dr. Raiff to account for feedstock inputs (section 6.3.2), wages (section 6.3.3), demand (section 6.3.4), interest rates (section 6.3.5), foreign exchange rates (section 6.3.6), Hurricanes Katrina and Rita (section 6.3.7), and the large reduction in capacity and the number of suppliers of TDI in 2005 (section 6.3.8). Based upon my review, experience, and training, Dr. Raiff's choice of potential variables and the supporting data are reasonable, supported by the record, and consistent with well-accepted econometric practices.
- (36) I agree with Dr. Raiff that variables included in a model should not be potentially affected by the alleged conspiracy, and that this principle is well-known in the field of econometrics and recognized by federal courts (Raiff Report paras. 241–242). I also agree with Dr. Raiff that his model accounts for the impact, if any, of the alleged “foamer” conspiracy on the prices of polyether polyol products (Raiff Report para. 243). Based on my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VI.D. Defendant sales data considerations (Raiff Report section 6.4)**

- (37) Paragraphs 266–268 of the Raiff Report explain Dr. Raiff's decision to rely upon Defendant-supplied data rather than less comprehensive Plaintiff-supplied data for quantities, prices, and other terms of individual transactions. Based upon my review, experience, and training, I conclude that Dr. Raiff's

<sup>25</sup> See, e.g., Deposition of Matthew E. Raiff, May 25–26, 2011 [hereinafter Raiff Dep. 2011], at 56 (“Q. All right. Fine. Are the coefficients of the independent variables that you chose to use in your model the same for the before period and the after period? A. That is not something that I'm doing here. I'm looking at doing the estimation over the entire sample. So the coefficients that are in the actual estimation is a blend of the regime that occurs in 1992-'93 along with the regime or the competitive dynamics that exist in the marketplace from 2004 through 2008. So that's what the model is estimating.”).



analysis and results are reasonable, supported by the record, and consistent with well-accepted econometric practices.

- (38) Paragraphs 269–270 of the Raiff Report explain Dr. Raiff's decision to model prices for three “benchmark” product categories—TDI 80/20, polymeric MDI, and CFS polyols—and to employ transaction-specific models to estimate prices for specific products. Based on my review, experience, and training, I conclude that this decision was reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VI.E. Benchmark product category models (Raiff Report section 6.5)**

- (39) Paragraphs 271–281 of the Raiff Report describe Dr. Raiff's econometric analysis of the benchmark product category models and the results of that analysis. Paragraph 282 of the Raiff Report explains that Dr. Raiff's models satisfied certain standard diagnostics and accurately predicted prices during the benchmark period.<sup>26</sup> Based on my review, experience, and training, I conclude that Dr. Raiff's analysis and results are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VI.F. Transaction-level models (Raiff Report section 6.6)**

- (40) Paragraphs 283–288 of the Raiff Report describe Dr. Raiff's econometric approach to the second step of his overcharge calculations. Based on my review, experience, and training, I conclude that Dr. Raiff's analysis and results are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VI.G. Calculation of damages (Raiff Report section 6.7)**

- (41) Paragraphs 289–291 of the Raiff Report explain how Dr. Raiff calculated overcharges on a transaction-by-transaction basis, with the overcharge equal to the difference between the actual price paid in the transaction and the estimated but-for price. Figures 63 and 64 summarize the purchases, overcharge percentages, and overcharges during the conspiracy period. Figures 65 and 66 summarize the purchases, overcharge percentages and overcharges during the class period. Based on my review, experience, and training, I conclude that Dr. Raiff's calculations are accurate and consistent with the instructions given to him by counsel, and that his estimates of overcharges are reasonable, supported by the record, and consistent with well-accepted econometric practices.

---

<sup>26</sup> In the Reply Report, Dr. Raiff explains that these diagnostics “showed that my model predicted nonconspiracy prices well and had a low residual autocorrelation.” Reply Report at 21, n. 84.

## VII. The Raiff Reply Report

- (42) Defendants' experts Dr. Keith Ugone and Professor Kenneth Elzinga submitted expert reports criticizing Dr. Raiff's analysis and conclusions. Dr. Ugone opined that Dr. Raiff's damage estimates are "overstated, flawed and unreliable," and Dr. Raiff "has not performed a full economic analysis relating to Direct Action Plaintiffs' claim of damages." Ugone Report para. 4.
- (43) I independently reviewed the criticisms made by Defendants and Defendants' experts as well as Dr. Raiff's responses. Based upon my review, experience, and training, I agree with Dr. Raiff that the asserted criticisms did not provide a legitimate reason for him to change his conclusions.<sup>27</sup>

### VII.A. Introduction (Reply Report section 2.1)

- (44) Paragraph 9 of the Reply Report explains that Defendants' experts claimed that "indicators of competition" prevent a finding of effective conspiracy. Paragraph 10 of the Reply Report explains that Dr. Raiff's analysis is premised on a jury finding the Defendants entered into illegal agreements to restrict competition, and hence Dr. Raiff's analysis addressed whether those agreements harmed the Plaintiffs and, if so, to what extent. Paragraphs 11–14 of the Reply Report explain how Dr. Raiff's analysis answers these questions and accounts for the "indicators of competition" cited by Defendants' experts.

### VII.B. Polyether polyol product prices are consistent with the existence of a conspiracy (Reply Report section 2.2)

- (45) Defendants' experts asserted that the existence of an effective conspiracy is inconsistent with the fact that polyether polyols prices did not experience a sustained rise during the conspiracy.<sup>28</sup> Paragraph 15 of the Reply Report explains that Defendants' experts fail to cite any economic support for this argument. Paragraphs 16–17 of the Reply Report explain that "virtually all conspiracies are imperfect" and provide examples of effective cartels in which prices remained stable or declined.<sup>29</sup> Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable and supported by the record.

---

<sup>27</sup> Section 1 of the Reply Report is an executive summary.

<sup>28</sup> Ugone Report at paras. 4, 66, 67; Elzinga Report at 64–66.

<sup>29</sup> Reply Report at para. 16.

### **VII.C. Price dispersion is consistent with the existence of a conspiracy (Reply Report section 2.3)**

- (46) Dr. Ugone asserted that variation in prices paid by Plaintiffs is inconsistent with the existence of an effective conspiracy.<sup>30</sup> Paragraphs 19–20 of the Reply Report explain that price dispersion does not prove or disprove the existence of a conspiracy and that price dispersion is consistent with the operation of an effective conspiracy. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VII.D. Supply and demand conditions during the allegation period are consistent with the existence of a conspiracy (Reply Report section 2.4)**

- (47) Defendants' experts asserted that the pattern of movements of input prices was inconsistent with the existence of an effective conspiracy.<sup>31</sup> Paragraphs 22–26 of the Reply Report explain that Dr. Raiff's econometric model incorporates input prices and accounts for them (para. 22), Defendants' experts' presentations were misleading (paras. 23–25), and Dr. Ugone relied upon superficial excerpts from trade publications whereas Dr. Raiff performed rigorous quantitative analysis (para. 26). Dr. Raiff concluded that the results of his econometric model demonstrate that increases in input costs do not fully account for the prices charged by Defendants during the conspiracy (para. 22).<sup>32</sup> Based upon my review, experience, and training, Dr. Raiff's conclusion is reasonable, supported by the record, and consistent with well-accepted econometric practices.
- (48) Dr. Ugone asserted that increased environmental regulations partially explain observed prices for polyols from 1994–1996.<sup>33</sup> Paragraph 27 of the Reply Report explains that there is little support for this assertion and that Dr. Ugone failed to demonstrate that increased environmental regulations had any effect on Defendants' costs or prices, or on the results of Dr. Raiff's analysis. Based upon my

<sup>30</sup> Ugone Report at paras. 4, 38, 46, 48.

<sup>31</sup> Ugone Report at paras. 4, 68; Elzinga Report at 66.

<sup>32</sup> The criticisms of Prof. Elzinga and Dr. Ugone relating to supply conditions in the industry are also rebutted by the evidence Dr. Raiff cited in paras. 205(a) and 206(f) of his initial report, where he identified three distinct episodes of potential or actual capacity restriction. These episodes show that Defendants attempted to, or did, reduce total industry-wide quantity below what it would have been but for the conspiracy. I discuss the importance of such evidence in a published article that I co-wrote with William Kovacic, former Commissioner of the Federal Trade Commission and current Global Competition Professor of Law and Policy at George Washington University's School of Law; Halbert White (now deceased), former Professor of Economics at the University of California, San Diego; and Robert Marshall, Professor of Economics and Head of the Economics Department, Pennsylvania State University. William E. Kovacic, Robert C. Marshall, Leslie M. Marx, and Halbert L. White, "Plus Factors and Agreement in Antitrust Law," *Michigan Law Review* 110, no. 3 (2011): 393–436. It is also described in *The Economics of Collusion*, a treatise that I co-authored with Dr. Marshall in 2012. Robert C. Marshall and Leslie M. Marx, *The Economics of Collusion: Cartels and Bidding Rings* (Cambridge, MA: MIT Press, 2012).

<sup>33</sup> Ugone Report at para. 76.

review, experience, and training, Dr. Raiff's conclusion is reasonable, supported by the record, and consistent with well-accepted econometric practices.

- (49) Dr. Elzinga asserted that Defendants' efforts to cut costs and operate more efficiently were inconsistent with the existence of a conspiracy.<sup>34</sup> Paragraph 28 of the Reply Report explains that cost-cutting measures by members of a cartel can be consistent with the existence of an effective conspiracy. Absent the conspiracy, even lower prices would have been observed. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VII.E. Customer switching and changes in the purchasing mix are consistent with the existence of a conspiracy (Reply Report section 2.5)**

- (50) Dr. Ugone asserted that "one would expect to find that the purchasing mix of the Direct Action Plaintiffs would be relatively stable during the claimed conspiracy,"<sup>35</sup> and Dr. Elzinga claimed that evidence of "active competition" demonstrates that a conspiracy could not have existed.<sup>36</sup> Paragraphs 29–33 of the Reply Report explain that Dr. Ugone conceded that customer switching could take place during a price-fixing conspiracy (n. 60), that Defendants' experts failed to offer economic authority for their assertions (para. 29), that active competition for customers can be consistent with successful conspiracies and has been observed in effective price-fixing conspiracies (paras. 30–31), that at times Defendants' executives criticized sales personnel for seeking business from customers traditionally associated with other Defendants (para. 32), and that a publication by Dr. Elzinga acknowledges the difficulty of observing stable market shares in a price-fixing conspiracy involving market allocation agreements (para. 33). Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VII.F. Alleged strategic differences among Defendants are consistent with the existence of a conspiracy (Reply Report section 2.6)**

- (51) Dr. Elzinga asserted that Defendants pursued different business strategies, calling into question whether they were involved in a conspiracy.<sup>37</sup> Paragraphs 34–37 of the Reply Report explain that Dr.

<sup>34</sup> See generally Elzinga Report at 29–63, but see Elzinga Report at 60 ("The strategic differences among the defendants reveal a pattern of behavior that is inconsistent with sustaining a cartel.") and 63 ("In short, my review of the defendants' strategies shows that they were not coordinated in a way that would be consistent with a cartel. In fact, the five defendants pursued strategies that differed from one another in ways that are fundamentally inconsistent with their having been parties to a cartel agreement.").

<sup>35</sup> Ugone Report at para. 52; see generally Ugone Report at paras. 52–65.

<sup>36</sup> Elzinga Report at section IV.D.

<sup>37</sup> Elzinga Report at 29.

Elzinga conceded that the pursuit of different business strategies does not disprove the existence of an effective cartel (para. 34), that different business strategies have been observed in effective cartels (para. 35), and that Defendants' business strategies were consistent with the operation of a cartel and benefitted from artificially inflated prices (paras. 36–37).<sup>38</sup> Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VII.G. Dr. Raiff's econometric model reflects widely recognized and well-established best practices (Reply Report section 3.1)**

- (52) Paragraph 38 of the Reply Report explains that Dr. Raiff carefully considered Dr. Ugone's criticisms of Dr. Raiff's econometric model and remains of the opinion that his model accounts for the relevant supply and demand factors influencing prices, Dr. Raiff followed best practices in the relevant academic literature, which also have been followed in other models accepted by the courts, and his model satisfies standard diagnostics of predicting prices well outside of the conspiracy period and having low residual autocorrelation. Figure 4 in Appendix A provides a summary of the model. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VII.H. Dr. Raiff's usage of weighted median prices is standard (Reply Report section 3.2)**

- (53) Dr. Ugone asserted that Dr. Raiff should not have modeled industry-wide prices in his benchmark price model.<sup>39</sup> Paragraphs 39–46 of the Reply Report explain that Dr. Ugone's assertion lacks academic support (para. 39), that the use of industry-wide prices is standard practice (para. 39), that Dr. Elzinga endorsed the use of aggregated prices and used them himself (para. 39), that the use of industry-wide prices is consistent with the allegation of an industry-wide price-fixing conspiracy (para. 40), and that there is substantial evidence that prices moved together and were driven by a common structure (paras. 41–46). Paragraphs 40 and 47–53 explain that Dr. Raiff's transaction-level model reliably accounts for price dispersion. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

<sup>38</sup> Dr. Raiff also provided evidence about firms' business strategies in his initial report at paras. 206(a) (Dow), 209 (BASF), and 212–213 (Bayer), and in the article cited in nn. 219–221 ("BASF's approach is straightforward: 'We do not accept new customers, this is an act of fairness to supply for our traditional customers,' said Reinmoller."). These episodes describe the pursuit of a price increase at a time when it is not warranted by business conditions, which is a sign that a firm is emphasizing price over additional sales volume. I discuss the importance of such evidence in Kovacic, Marshall, Marx, and White (2011) and Marshall and Marx (2012).

<sup>39</sup> Ugone Report at paras. 4, 32–48.

### **VII.I. Dr. Raiff's model relies upon appropriate supply and demand variables (Reply Report section 3.3)**

- (54) Dr. Ugone claimed that Dr. Raiff's model "failed to properly account for two important variables: capacity and demand."<sup>40</sup> With respect to capacity, paragraph 55 of the Reply Report explains that Dr. Raiff accounted for changes in the industry in 2005 that affected capacity and that capacity is already accounted for in the econometric model because capacity is related to the supply and demand variables that also affect prices and are included in the econometric model. Paragraph 56 of the Reply Report explains that including a capacity variable in Dr. Raiff's model did not change the estimated overcharges. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.
- (55) With respect to demand, paragraphs 57–59 of the Reply Report describe the numerous variables included in Dr. Raiff's model that account directly or indirectly for demand (paras. 57, 59), and explain that including the only additional variable proposed by Dr. Ugone (i.e., the durable consumption goods industrial production index) did not change the results (para. 57). Paragraph 59 of the Reply Report also explains that Dr. Raiff's model accounts indirectly for demand effects via their relationship with supply and demand variables that are included in the model, and for effects of the alleged "foamer" conspiracy via its relationship with demand variables included in the model. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VII.J. Dr. Raiff's model uses an appropriate estimation technique (Reply Report section 3.4)**

- (56) Dr. Ugone asserted that Dr. Raiff used inappropriate, inconsistent approaches for selecting variables to incorporate into his model.<sup>41</sup> Paragraphs 60–62 of the Reply Report explain that Dr. Raiff used complementary approaches (para. 60), relied upon his study of the urethanes industry and his professional judgment to identify key variables for inclusion in his model (para. 61), and employed a standard statistical procedure known as "AIC" to determine whether including additional variables improved the performance of his model without "overfitting" (para. 62). Paragraph 63 of the Reply Report explains that this approach is well-supported in the econometric literature. Paragraphs 64–66 of the Reply Report explain that two exercises performed by Dr. Ugone are flawed because key variables are omitted. Paragraphs 67–70 explain that Dr. Ugone failed to offer a model of his own (para. 67), and erroneously criticized Dr. Raiff's approach as a "stepwise" regression procedure when in fact it is not (paras. 68–70). I agree with Dr. Raiff that Dr. Ugone failed to offer a model of his

---

<sup>40</sup> Ugone Dep. at 625–640; Ugone Report at paras. 74–75.

<sup>41</sup> Ugone Report at paras. 163, 172–179.



own and that Dr. Raiff's approach is not a "stepwise" regression. Based upon my review, experience, and training, Dr. Raiff's approach to variable selection is reasonable, supported by the record, and consistent with well-accepted econometric practices. Like Dr. Raiff, I also disagree with Dr. Ugone's assertion<sup>42</sup> that Dr. Raiff should have used one technique or the other, but not both, because that assertion is without economic support or logic.

### **VII.K. Dr. Ugone's modifications to Dr. Raiff's model are inappropriate (Reply Report section 3.5)**

- (57) Dr. Ugone performed sensitivity tests in which he modified Dr. Raiff's model by (1) using more disaggregated data than Dr. Raiff to estimate benchmark product models,<sup>43</sup> (2) using different data than Dr. Raiff to estimate transaction-level models,<sup>44</sup> and (3) omitting 2004 data from the benchmark period.<sup>45</sup> Dr. Raiff considered these analyses and remained of the opinion that his models are reliable. As I now explain, based upon my review, experience, and training, Dr. Raiff's conclusion is reasonable, supported by the record, and consistent with well-accepted econometric practices.

#### **VII.K.1. Dr. Ugone's usage of disaggregated data results in a less reliable and comprehensive alternative to Dr. Raiff's econometric model (Reply Report section 3.5.1)**

- (58) Dr. Ugone criticized Dr. Raiff for modeling a single industry-wide price line for each benchmark product.<sup>46</sup> Dr. Ugone constructed alternative models of separate benchmark product price lines for individual Defendants, and asserted that the different results yielded by his Defendant-specific models "cast doubt" on the reliability of Dr. Raiff's models and methodology.<sup>47</sup>
- (59) Paragraphs 72–73 of the Reply Report explain that the manner in which Dr. Ugone used disaggregated data is well-known in the scientific literature to inject artificial "noise," i.e., variability, into a model, and to reduce available data to such a degree that reliable estimation of a disaggregated model can become impossible (paras. 72–73). Paragraph 73 of the Reply Report also explains that Dr. Ugone admits that he was unable to estimate reliable models for some Defendants and products "due to a lack of data" and "very high variability."<sup>48</sup> Paragraphs 74–76 and Figures 7 and 8 of the

<sup>42</sup> Dr. Ugone reported the results of estimating models by using only one technique or the other: "I use 'Full Choice' as shorthand for allowing the model to choose amongst all variables and 'Key Variables' as shorthand for forcing the models to only include Dr. Raiff's 'key' supply and demand variables." Ugone report at 128, Table 8.

<sup>43</sup> Ugone Report at para. 4(i).

<sup>44</sup> Ugone Report at para. 4(k).

<sup>45</sup> Ugone Report at para. 4(d).

<sup>46</sup> Ugone Report at paras. 181–184.

<sup>47</sup> Ugone Report at para. 184.

<sup>48</sup> Ugone Report at para. 182 in notes to Table 1.

Reply Report provide examples of how using Defendant-specific data introduced problematic statistical “noise” and removed so much data that reliable Defendant-specific modeling was impossible. It is clear from Figures 7 and 8 of the Reply Report that Defendant-specific data individually do not always reliably reflect prices. Based upon my review, experience, and training, Dr. Raiff’s conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices. In my opinion, Dr. Raiff reliably modeled industry-wide benchmark product prices and Dr. Ugone’s alternative is an inferior, less comprehensive approach.

### **VII.K.2. Dr. Ugone’s transaction-level models corroborate Dr. Raiff’s results (Reply Report section 3.5.2)**

- (60) Dr. Ugone criticized Dr. Raiff’s approach of estimating transaction-level models using combined data for all direct action plaintiffs, and offered as alternatives (1) combining data for class plaintiffs with direct action plaintiffs’ data and (2) estimating separate models for individual direct action plaintiffs.<sup>49</sup> Paragraphs 77–83 of the Reply Report explain that Dr. Ugone’s modifications produce results that are very similar to Dr. Raiff’s and corroborate Dr. Raiff’s results and methodology. Based upon my review, experience, and training, Dr. Raiff’s conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices. In my opinion, Dr. Raiff’s transaction-level models are appropriate and reliable.

### **VII.K.3. The 2004 data belong in the benchmark period (Reply Report section 3.5.3)**

- (61) Dr. Raiff was instructed by counsel for Plaintiffs to assume that the alleged conspiracy ended by December 2003 (Raiff Report para. 1). Dr. Ugone criticized Dr. Raiff for including 2004 data in the benchmark period.<sup>50</sup> Dr. Raiff considered Dr. Ugone’s criticisms and concluded that 2004 is more appropriately treated as part of the benchmark period (Reply Report paras. 85–86). Based upon my review, experience, and training, Dr. Raiff’s conclusion is reasonable, supported by the record, and consistent with well-accepted econometric practices.
- (62) Dr. Ugone omitted 2004 data (12 monthly observations) from the benchmark period and found that doing so caused large changes in the results of Dr. Raiff’s model.<sup>51</sup> Paragraph 84 of the Reply Report explains that this is not surprising given the large amount of important data removed by Dr. Ugone. The 2004 data comprises 60% of available data between the assumed end of the conspiracy in December 2003 and the structural changes to the industry that took place in 2005.

---

<sup>49</sup> Ugone Report at paras. 195–198.

<sup>50</sup> Ugone Report at paras. 128–131.

<sup>51</sup> Ugone Report at paras. 128–131.



- (63) Dr. Raiff conducted additional investigation regarding 2004. Paragraphs 88–90 of the Reply Report describe evidence suggesting that the conspiracy had ended or was at least seriously weakened by the end of 2003: in September and December of 2002, Bayer was raided twice by government officials investigating price-fixing in the rubber chemicals and EPDM industries (para. 90); in early 2003, Bayer conducted an internal investigation into its involvement in ESRB price-fixing and applied for and received immunity (para. 90); following the raids of September and December of 2002, Bayer placed a heightened emphasis on antitrust compliance (para. 88); Bayer stopped participating in discussions with other defendants about raising urethanes prices and about industry conditions by the end of 2003 (para. 88); and a number of executives that participated in the conspiracy left their respective positions or companies by the end of 2003 due to internal reorganizations (para. 90).<sup>52</sup>
- (64) Dr. Raiff considered the possibility that the conspiracy ended by September 2003 (when Bayer's Christian Buhse told Dow's Marco Levi and BASF's Uwe Hartwig that he would no longer participate in discussions regarding raising prices and industry conditions, and stopped doing so<sup>53</sup>), and that lingering effects of collusion persisted throughout the remainder of 2003 and 2004. Paragraph 91 of the Reply Report explains that there were no such lingering effects into 2004 because Dr. Raiff's model predicts zero overcharges at the end of 2003. This is apparent from inspection of the but-for and actual prices. For polyols and MDI, there are no positive overcharges after September 2003 and October 2003, respectively, when the but-for price lines for these products rose above the actual price lines and remained above the actual price lines. For TDI, overcharges are negative in October 2003 but positive in November (0.3%) and December (2.8%). However, in January 2004 the TDI prediction error increases to 6.2%, which is inconsistent with lingering effects: overcharges would be expected to fall, not rise, with the conspiracy's end.<sup>54</sup>
- (65) Paragraph 87 of the Reply Report states that Dr. Raiff tested and found that the average prediction errors of his model in 2004 are not statistically different from zero. I was unable to determine the basis for this statement from the backup materials and I did not have access to Dr. Raiff. I therefore cannot agree or disagree with this particular statement. In my opinion, however, this additional test is not necessary to justify Dr. Raiff's decision to include 2004 in the benchmark period. I note that Dr. Raiff's model overall predicts prices well during 2004. The predicted prices for MDI and polyols in 2004 are above the actual prices, which is the opposite of what one would expect if a conspiracy had increased prices in 2004.

<sup>52</sup> I have spoken with outside counsel for Bayer and confirmed the information provided in para. 88 of the Reply Report.

<sup>53</sup> E-mail from Jodi Trulove, Plaintiffs' counsel, Dickstein Shapiro LLP, to Philip A. Proger, counsel for Bayer, Jones Day (May 22, 2012) ("At a meeting in September 2003 among Mr. Buhse, Uwe Hartwig of BASF and Marco Levi of Dow, held at Mr. Hartwig's house in Belgium, Mr. Buhse told Messrs. Hartwig and Levi that that he would not participate in any further discussions regarding raising prices and market conditions. According to Mr. Buhse, Messrs. Hartwig and Levi tried to convince Mr. Buhse to continue the discussions and proposed that they agree to stability of market shares, but Mr. Buhse refused and did not engage in any further pricing discussions with urethanes competitors.").

<sup>54</sup> Estimating overcharges on purchases in the fourth quarter of 2003 is conservative because the net effect is to reduce total overcharges. *Infra* para. (92).

### **VII.L. Dr. Ugone inappropriately interprets Dr. Raiff's coefficient estimates and their statistical significance (Reply Report section 3.6)**

- (66) Dr. Ugone asserted that Dr. Raiff's benchmark price models are "nonsensical" because some of the estimated coefficients have signs that are inconsistent with economic theory and common sense, or are statistically insignificant.<sup>55</sup> Paragraphs 92–98 of the Reply Report explain that Dr. Ugone misinterprets the coefficients of Dr. Raiff's models. Predictive models such as Dr. Raiff's are designed to predict prices rather than measure the impact of individual economic variables on price (para. 92). Estimated coefficients of individual variables may reflect the influence of multiple variables on price (paras. 93–95). Predictive models are not designed to test whether a particular variable has a statistically significant effect on price (paras. 96–98). The appropriate measure of performance for Dr. Raiff's models is predictive accuracy rather than the sign or statistical significance of individual coefficients. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

### **VII.M. Dr. Ugone failed to properly test the predictive performance of Dr. Raiff's model (Reply Report section 3.7)**

- (67) Dr. Ugone asserted that Dr. Raiff's model is unreliable because it does not accurately predict post-conspiracy prices when estimated using only pre-conspiracy data, and vice versa.<sup>56</sup> Paragraph 100 of the Reply Report explains that such a result is not surprising given the large amounts of data excluded by Dr. Ugone and the importance of post-conspiracy events such as the restructuring of the industry and natural disasters such as Hurricanes Katrina and Rita. Paragraph 101 of the Reply Report explains that Dr. Raiff's model utilized all available non-conspiracy data and appropriately allowed the relationships between prices and supply and demand variables to differ during the post-conspiracy period. Paragraph 102 of the Reply Report explains (citing section 3.8.3 of the Reply Report) that Dr. Raiff's model predicts benchmark period prices accurately, confirming that it properly accounts for changes that occurred in the industry and is reliable. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

<sup>55</sup> Ugone Report at paras. 4(g), 168–171.

<sup>56</sup> Ugone Report at paras. 118, 132–135. Dr. Ugone also used a model estimated by using 1992, 1993 and 2004 data to predict prices in 2005–2008 and a model estimated by using 2005–2008 data to predict prices in 1992, 1993, and 2004. Ugone Report at 101, n. 289. Dr. Ugone also estimated a model by using 1992–1993 and 2005–2008 data to predict prices in 2004. Ugone Report at para. 118. In addition, Dr. Ugone estimated models after removing certain years from the benchmark period. Specifically, he estimated a model after removing 2005, a model after removing 2006, a model after removing 2007, and a model after removing 2008. Ugone Report at 99, n. 288 and back-up materials pertaining to that footnote.

- (68) I have considered Dr. Ugone's attempted tests of predictive performance in conjunction with a broad range of factors bearing on the reliability of Dr. Raiff's models (see paragraph (80) below).<sup>57</sup> Based upon my review, experience, and training, I agree with Dr. Raiff's conclusion that his models are reliable.
- (69) Dr. Ugone's exercises fundamentally consist of estimating models that are deprived of important benchmark data, and then highlighting deficiencies in the predictions of these models.<sup>58</sup> For instance, Dr. Ugone excluded all of 2004 from the benchmark data,<sup>59</sup> and all of 2008 (the year of the Great Recession) from the benchmark data.<sup>60</sup> Dr. Ugone then argued that because predictions of these models (which lack important benchmark data) are deficient, then so must Dr. Raiff's models (whose only difference from Dr. Ugone's models is to include all available benchmark data) be deficient. I disagree with Dr. Ugone, and agree with Dr. Raiff that Dr. Ugone's exercises serve only to highlight the importance of using all the benchmark data.<sup>61</sup> Defendants' conspiracy is alleged to have operated for ten years, and only seven years of benchmark data are available. Defendants' conspiracy divides the benchmark data into two parts: two years before the conspiracy and five years after it. Furthermore, structural changes in the industry divide the post-conspiracy benchmark data into three parts: approximately a year and a half before those changes occurred, approximately half a year during which those changes occurred, and three years of data following those changes. I disagree with Dr. Ugone that these exercises show that Dr. Raiff's model is unreliable, especially given all the other indications of reliability.
- (70) As authority for his exercises, Dr. Ugone cited two sources: an ABA book and an econometrics textbook by Stock and Watson.<sup>62</sup> Dr. Raiff explained that "Dr. Ugone has no basis to reference" the ABA book that Dr. Ugone cited as an authority for his exercises because the ABA book's "test was applied in a different context from the one here."<sup>63</sup> Moreover, the cited discussion in Stock and

<sup>57</sup> Dr. Ugone claims that some of his models provide good dynamic predictions. *See, e.g.*, Ugone Report at 99 n. 287 (claiming the model excluding 2004 from the benchmark has predicted prices that "resemble the actual prices over" 2005–2008). However, it is important to consider any model in conjunction with a broad range of factors bearing on the model's reliability.

<sup>58</sup> Dr. Ugone commits this type of error throughout his analysis. As one example, Dr. Ugone estimates his own models excluding key cost and demand variables and claims his models' deficient predictions prove Dr. Raiff's model, which includes those key cost and demand variables, is unreliable. *See* sections VII.J and VII.P.1. As another example, Dr. Ugone estimates his own models using Defendant-specific price lines that do not always reliably reflect market prices, and then he claims his models' deficient predictions prove Dr. Raiff's model, whose industry-wide prices properly reflect market prices, is unreliable. *See* section VII.K.1. These approaches are all unreasonable in my opinion, and Dr. Ugone concedes that what matters "is the sensitivity of the results to *reasonable* changes in the assumptions." Ugone Report 96 n. 281, citing Epstein, Roy J., "An Econometric Primer for Lawyers," *Antitrust* 25, no.3 (2011): 29–33, at 33 (emphasis added).

<sup>59</sup> Ugone Report at para. 121.

<sup>60</sup> Ugone Report at 99, n. 288 and at 117, n. 323.

<sup>61</sup> Reply Report at para. 101.

<sup>62</sup> Ugone Report at para.119, at 97 n. 284, and at 99 n. 288 (ABA book), and at 117 n. 323 (econometrics textbook).

<sup>63</sup> Reply Report at 45 n. 157.

Watson addresses a different type of forecasting exercise than the one performed by Dr. Raiff. The excerpt to which Dr. Ugone refers relates to regression models used for “real time” forecasting—i.e., forecasting of future values of economic variables using data available today. But this is not what Dr. Raiff did, nor what he was asked to do. Dr. Raiff was asked to estimate what competitive prices would have been during a period of time in the past. Dr. Raiff constructed a model that provides a reliable measure of those prices using benchmark data from both before and after the conspiracy period which, as I note above, is consistent with well-accepted economic practices. Based upon my review, experience, and training, Dr. Raiff’s conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

- (71) The assessment of econometric models such as those employed by Dr. Raiff is a matter of professional judgment based on a variety of factors (see paragraph (80) below), including but not limited to model diagnostics such as  $R^2$  and residual autocorrelation and how well a model predicts actual data. Specifically, dynamic predictive models, such as those estimated by Dr. Raiff, can be assessed by examining how well their predictions track the data in the benchmark period when the prediction is started at the beginning of the benchmark period. Such a dynamic prediction is constructed by starting the model at the beginning of the benchmark period and then allowing the model’s predictions to run forward in time. The model is never informed of the actual price level at any subsequent point in time and, consequently, the predictions can depart from actual values by growing unreasonably large or small.<sup>64</sup> The back-up materials accompanying the Reply Report include predictions for Dr. Raiff’s models that were constructed by starting the models at the beginning of the benchmark period. As shown in Figure 5, Figure 6, and Figure 7 in Appendix A, these predictions track the data in the benchmark period well. In contrast, Dr. Ugone’s models provide examples of poor dynamic prediction. For instance, the benchmark MDI model Dr. Ugone reports in Exhibit 55, which was estimated by using only post-conspiracy data, predicts that prices should have fallen from \$0.71 in January 1992 to \$0.21 in December 1993, when actual prices were largely flat over 1992–1993. Similarly, the benchmark MDI model Dr. Ugone reports in Exhibit 54, which was estimated by using only pre-conspiracy data, predicts that prices should have fallen from approximately \$0.97 to \$0.58 from December 2004 to December 2008, while actual prices rose to \$1.13.

## **VII.N. Dr. Raiff’s overcharges measure the impact of Defendants’ conspiracy on prices (Reply Report section 3.8)**

- (72) Dr. Ugone asserted that Dr. Raiff’s benchmark MDI and polyols models are unable to establish that the alleged conspiracy was the cause of the differences between actual and but-for prices.<sup>65</sup> Dr.

<sup>64</sup> Dynamic predictions are *not* fitted values. Fitted values in the benchmark period are mathematically constrained to match, on average, actual values. Dynamic predictions are not so constrained.

<sup>65</sup> Ugone Report at paras. 136–140.

Ugone's rationale was that the overcharges predicted by Dr. Raiff's benchmark MDI and polyols models were not statistically different from zero, and therefore lacked sufficient precision to establish the existence of Plaintiffs' damages.<sup>66</sup> Dr. Ugone did not criticize Dr. Raiff's benchmark TDI model on this basis.

- (73) Dr. Raiff considered Dr. Ugone's criticisms and remained of the opinion that his benchmark models measure the impact of the alleged conspiracy on prices. Paragraphs 103–107 of the Reply Report explain that Dr. Raiff constructed his model specifically to estimate the effect of the alleged conspiracy on prices, followed best practices to account for factors other than the alleged conspiracy that might have affected prices, and drew upon well-accepted econometric tools developed in a large volume of peer-reviewed scientific literature. Based on my experience and training, Dr. Raiff's discussion is appropriate and, as Dr. Raiff observes in Paragraph 108 of the Reply Report, Dr. Ugone failed to reference, respond to, or rebut the scientific literature cited by Dr. Raiff. Dr. Ugone instead based his critique of Dr. Raiff's model largely upon a five-page "Econometric Primer" which was designed to provide a practical, nontechnical explanation of econometric basics to a lay audience. While that Primer may be useful for its limited purpose, it does not rebut any of the materials on which Dr. Raiff relied and does not relate to the type of dynamic predictive model that Dr. Raiff estimated. Based upon my review, experience, and training, I agree with Dr. Raiff's conclusion that his benchmark MDI and polyols models are reliable.

#### **VII.N.1. Dr. Ugone incorrectly calculated the confidence intervals he reported (Reply Report section 3.8.1)**

- (74) Dr. Ugone asserted that he estimated 95% confidence intervals for Dr. Raiff's predicted but-for prices and found that predicted but-for prices for the benchmark MDI and polyols models were not statistically different from the respective actual prices.<sup>67</sup>
- (75) In his Reply Report (paras. 110–113), Dr. Raiff stated that the confidence intervals computed by Dr. Ugone are unreliable for two reasons: (a) the calculations were performed using a computer program command that, according to the program documentation, could generate an incorrect answer; and (b) the calculations did not correctly handle the variables accounting for the industry changes in 2005 included in Dr. Raiff's models. I agree with Dr. Raiff's conclusion that Dr. Ugone's confidence intervals are not properly calculated.
- (76) At his deposition, Dr. Ugone testified that he was not aware that his confidence interval calculations relied on a command that could generate an incorrect answer and did not know why his calculations

---

<sup>66</sup> Ugone Report at paras. 137, 140.

<sup>67</sup> Ugone Report at para. 140.

relied on the command.<sup>68</sup> Dr. Ugone has not amended his report or offered further clarification of his opinion.

- (77) During Dr. Raiff's deposition, counsel for Dow produced an email apparently from Stata dated subsequent to Dr. Ugone's deposition.<sup>69</sup> The email from Stata suggests that the program command used to compute Dr. Ugone's confidence intervals disregards some components necessary to calculate a confidence interval properly. The email does not address the fact that Dr. Ugone's calculations did not properly account for some of the variables included in Dr. Raiff's model.
- (78) During Dr. Raiff's deposition, counsel for Dow also produced an excerpt from an econometrics textbook indicating that a "method known as bootstrapping" is recognized in the literature as a proper approach to construct confidence intervals when confidence intervals are otherwise "simply intractable" to compute.<sup>70</sup>
- (79) Regardless, even if Dr. Ugone had calculated his confidence intervals correctly, I agree with Dr. Raiff that his econometric model is reliable. Nevertheless, I address these issues raised at Dr. Raiff's deposition in the following section, in which I address confidence intervals for aggregate overcharges rather than for monthly but-for prices.<sup>71</sup>

### **VII.N.2. Confidence intervals and hypothesis testing (Reply Report section 3.8.2)**

- (80) Paragraphs 115–116 of the Reply Report explain that Dr. Raiff carefully designed his models to account for important supply and demand variables that influenced prices during the benchmark period; that Dr. Raiff's models predict actual prices during the benchmark period well; that the results of Dr. Raiff's models are consistent with one another despite using different combinations of supply and demand variables; that estimated overcharges for the benchmark products are similar in overall magnitude and patterns over time; that there is substantial evidence that Defendants did in fact collude on prices of TDI, MDI and polyols; and that Dr. McClave (the expert retained by the class plaintiffs) independently arrived at overcharge estimates that were similar to Dr. Raiff's. Dr. Raiff

---

<sup>68</sup> Ugone Dep. at 681–692.

<sup>69</sup> Deposition of Matthew E. Raiff, June 27, 2012 [hereinafter Raiff Dep. 2012], at ex. 8725.

<sup>70</sup> Raiff Dep. 2012 at ex. 8726 at 87 ("The preceding discussion assumes that  $\mathbf{x}^0$  is either known with certainty, ex post, or has been forecast perfectly, ex ante. If  $\mathbf{x}^0$  must, itself, be forecasted (an ex ante forecast), then the formula for the forecast variance in (4-46) would have to be modified to incorporate the uncertainty in forecasting  $\mathbf{x}^0$ . . . . This will vastly complicate the computation. Many authors view it as simply intractable . . . McCullough (1996) presents an alternative approach to computing appropriate forecast standard errors based on the method of bootstrapping.").

<sup>71</sup> In Figure 10 of his Reply Report, Dr. Raiff presented the results of a hypothesis test for aggregate overcharges. I agree with Dr. Raiff in that the statistical uncertainty about aggregate overcharges is the appropriate object of interest, rather than the uncertainty about estimated but-for prices in any particular month. The statistical uncertainty about aggregate overcharges considers the evidence in its totality, while the uncertainty about estimated but-for prices in any particular month considers that particular month in isolation.



also (a) used a methodology grounded in the literature<sup>72</sup> and the facts of the case,<sup>73</sup> (b) carefully handled the data,<sup>74</sup> (c) has a model that performs well<sup>75</sup> and produces sensible results that were confirmed by various sensitivity analyses,<sup>76</sup> and (d) followed an overall conservative approach.<sup>77</sup> Based upon my review, experience, and training, these factors are sufficient to show that Dr. Raiff performed a sound, professional, and reliable analysis of overcharges to Plaintiffs.

- (81) Paragraph 120 and Figure 10 of the Reply Report explain that Dr. Raiff calculated a “p-value” for each benchmark model, which represents the statistical probability of a “false positive” (i.e., a prediction of overcharges) if no overcharge exists. The p-values are 0.4% for the benchmark TDI model’s overcharges, 7.2% for the benchmark polyols model’s overcharges, and 19.2% for the benchmark MDI model’s overcharges.<sup>78</sup> Dr. Raiff explained that “[t]hese low probabilities are evidence that there was an effective conspiracy that caused plaintiffs economic harm in the amounts estimated by my models.”<sup>79</sup>
- (82) I agree with Dr. Raiff that these probabilities are evidence that there was an effective conspiracy that caused plaintiffs to be overcharged in the amounts estimated by Dr. Raiff. Given that Dr. Raiff’s models were designed in accordance with well-accepted econometric practices, perform well, and produce sensible results,<sup>80</sup> I also agree with Dr. Raiff that no further confirmation is necessary.<sup>81</sup>

<sup>72</sup> Reply Report at paras. 103–108; Raiff Report at paras. 229–233.

<sup>73</sup> Raiff Report at paras. 235–239, Reply Report at paras. 88–91 (on selection of appropriate benchmark period); Raiff Report at paras. 240–242, 245–248, and Reply Report at paras. 54–59 (on selection of appropriate supply and demand variables).

<sup>74</sup> Raiff Report at paras. 267–269, 272, 285–288, and app. E.

<sup>75</sup> Raiff Report at para. 282; Reply Report at para. 38.

<sup>76</sup> Reply Report at paras. 54–59 (considering additional demand and capacity variables); para. (71) above (describing dynamic forecast from start of benchmark period).

<sup>77</sup> Raiff Report at 129, n. 354 (not calculating overcharges on “outlier” purchases); Raiff Dep. 2011 at 604 (crediting Defendants with negative overcharge amounts).

<sup>78</sup> Dr. Raiff performed a one-tailed test, which is also known as a one-sided test. I agree with Dr. Raiff in that a one-tailed hypothesis test is the relevant test here because the issue is whether the Defendants’ alleged conspiracy raised prices. *See, e.g.,* James H. Stock and Mark W. Watson, *Introduction to Econometrics*, 3rd ed. (Boston: Addison Wesley, 2011) at 78–79 (“In some circumstances, the alternative hypothesis might be that the mean exceeds  $\mu_{Y,0}$ . For example, one hopes that education helps in the labor market, so the relevant alternative to the null hypothesis is that earnings are the same for college graduates and non-college graduates is not just that their earnings differ, but rather than graduates earn more than non-graduates.”); Jeffrey M. Wooldridge, *Introductory Econometrics: A Modern Approach*, 4th ed. (Mason, OH: South-Western, 2010) at 123–25 (A one-sided hypothesis test “means that we do not care about [two-sided] alternatives . . . for some reason, perhaps on the basis of introspection or economic theory, we are ruling [them] out”) and Examples 4.1, 4.2, 4.4, C.4, C.5, C.6, C.9 (performing one-sided tests); Daniel L. Rubinfield, “Reference Guide to Multiple Regression,” in *Reference Manual on Scientific Evidence*, 3rd ed. (Washington, DC: The National Academies Press, 2011) at 303–57, *but see* 321 (“A one-tailed test would usually be applied when the expert believes, perhaps on the basis of other direct evidence presented at trial, that the alternative hypothesis is either positive or negative, but not both. For example, an expert might use a one-tailed test in a patent infringement case if he or she strongly believes that the effect of the alleged infringement on the price of the infringed product was either zero or negative.”).

<sup>79</sup> Reply Report at para. 120.

<sup>80</sup> *See* para. (80).

<sup>81</sup> Reply Report at para. 116.

- (83) I also agree with Dr. Raiff (Reply Report paras. 116–120) that the fact that the p-values for the overcharges of the benchmark MDI and polyols models exceed 5% (Dr. Ugone’s proposed threshold)<sup>82</sup> should be viewed in the context of other factors such as sound design, implementation, and performance of Dr. Raiff’s models,<sup>83</sup> and the evidence that Defendants conspired effectively for an extended period of time, and when they are, establish that the alleged conspiracy did cause his estimated overcharges.
- (84) Given the issues with Dr. Ugone’s calculations described in the section above, using the same data on which Dr. Ugone relied, I have calculated 95% confidence intervals for the overcharges estimated by Dr. Raiff. The calculation of confidence intervals for dynamic predictive models such as those employed by Dr. Raiff is technically complex. I used a bootstrap approach that accounts for statistical uncertainty to quantify the uncertainty surrounding the estimated overcharges.<sup>84</sup>
- (85) Results are portrayed in Figure 1, Figure 2, and Figure 3.<sup>85</sup> In each figure, the 95% confidence interval that Dr. Ugone proposed is given by the range of the bootstrapped overcharges.<sup>86</sup> Dr. Raiff’s estimated overcharges are contained within the bar shaded in red. The height of each bar indicates how frequently the bootstrapped overcharges fell within the particular range of overcharges corresponding to that bar.

---

<sup>82</sup> Ugone Report at para. 139.

<sup>83</sup> See para. (80).

<sup>84</sup> The bootstrap approach is commonly used throughout the literature in situations akin to this case. See, e.g., Bradley Efron and Robert Tibshirani, *An Introduction to the Bootstrap*, vol. 57 (Boca Raton, FL: CRC Press, 1993) at 60–61 (“Before the computer age statisticians calculated standard errors using a combination of mathematical analysis, distributional assumptions, and, often, a lot of hard work on mechanical calculations...Computer-based methods like the bootstrap free the statistician from these constraints. Standard errors, and other measures of statistical accuracy, are produced automatically, without regard to mathematical complexity.”); William H. Greene, *Econometric Analysis*, 7th ed. (Upper Saddle River, NJ: Prentice Hall, 2007) at 611 (“The technique of **bootstrapping** is used to obtain a description of the sampling properties of empirical estimators using the sample data themselves, rather than broad theoretical results.”) (emphasis in original).

<sup>85</sup> The results in Figure 1, Figure 2, and Figure 3 are for one-tailed 95% confidence intervals, which is consistent with the one-tailed hypothesis tests performed in the Reply Report. See *supra* n. 78. One-sided confidence intervals are the confidence interval analog of one-sided hypothesis tests. See Bradley and Tibshirani (1993) at 214 (“There is an intimate connection between hypothesis testing and confidence intervals.”); George Casella and Roger L. Berger, *Statistical Inference* (Belmont, CA: Wadsworth, 1990) at 410 (“The test inversion method is completely general in that we can invert any test and obtain a confidence set . . . note that the inversion of a two-sided test gave a two-sided interval. In the next examples, we invert one-sided tests to get one-sided intervals.”).

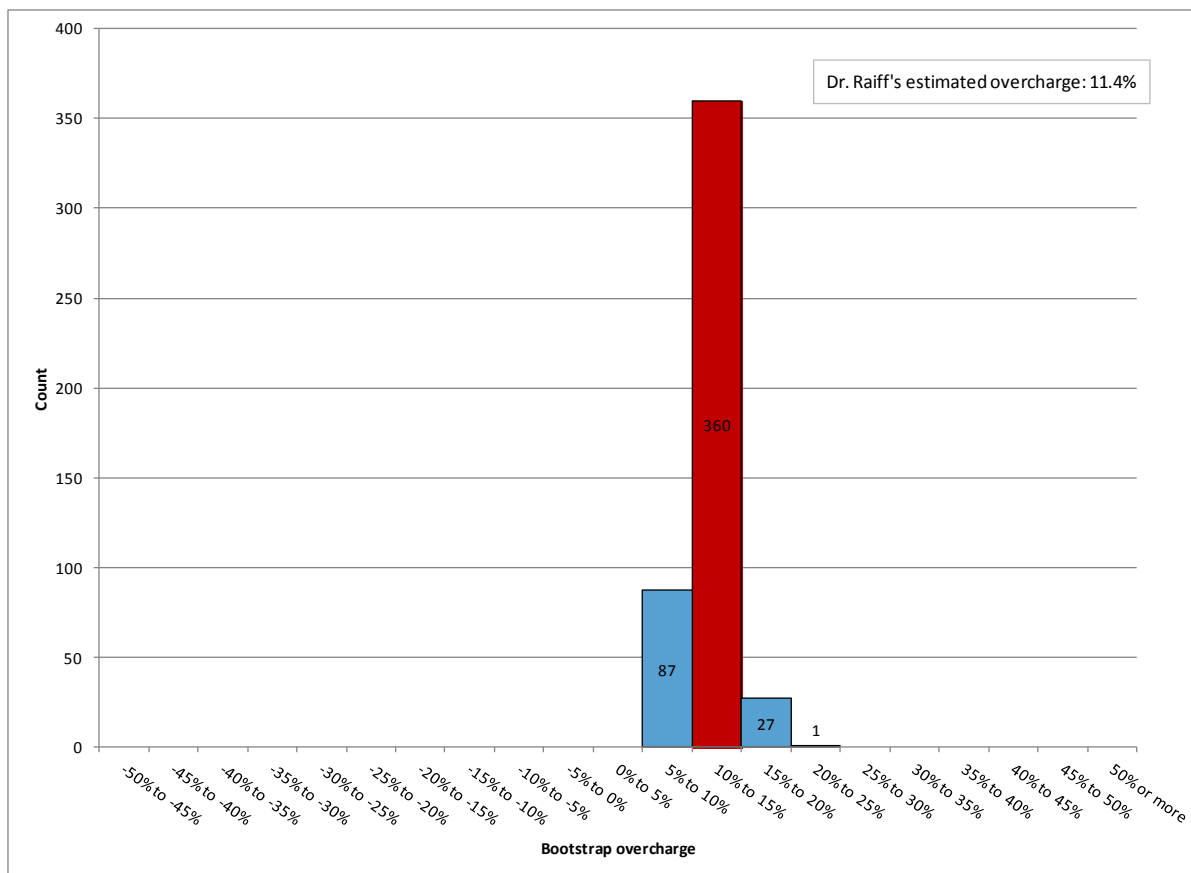
If one were to calculate a two-sided 90% confidence interval, then one would simply omit the 25 largest values from Figure 1, Figure 2, and Figure 3. So in Figure 2, the 13 bootstrapped overcharges in the “50% or more” bin would be omitted, the 7 bootstrapped overcharges in the “45% to 50%” bin would be omitted, and 5 of the 8 bootstrapped overcharges in the “40% to 45%” bin would be omitted. It is thus clear that the distributions of aggregate overcharges at 95% confidence do not differ substantially whether one is examining one- or two-sided confidence intervals; hence, I would reach the same conclusions.

<sup>86</sup> For instance, the 95% confidence interval for TDI overcharges is between 5% and 25%.



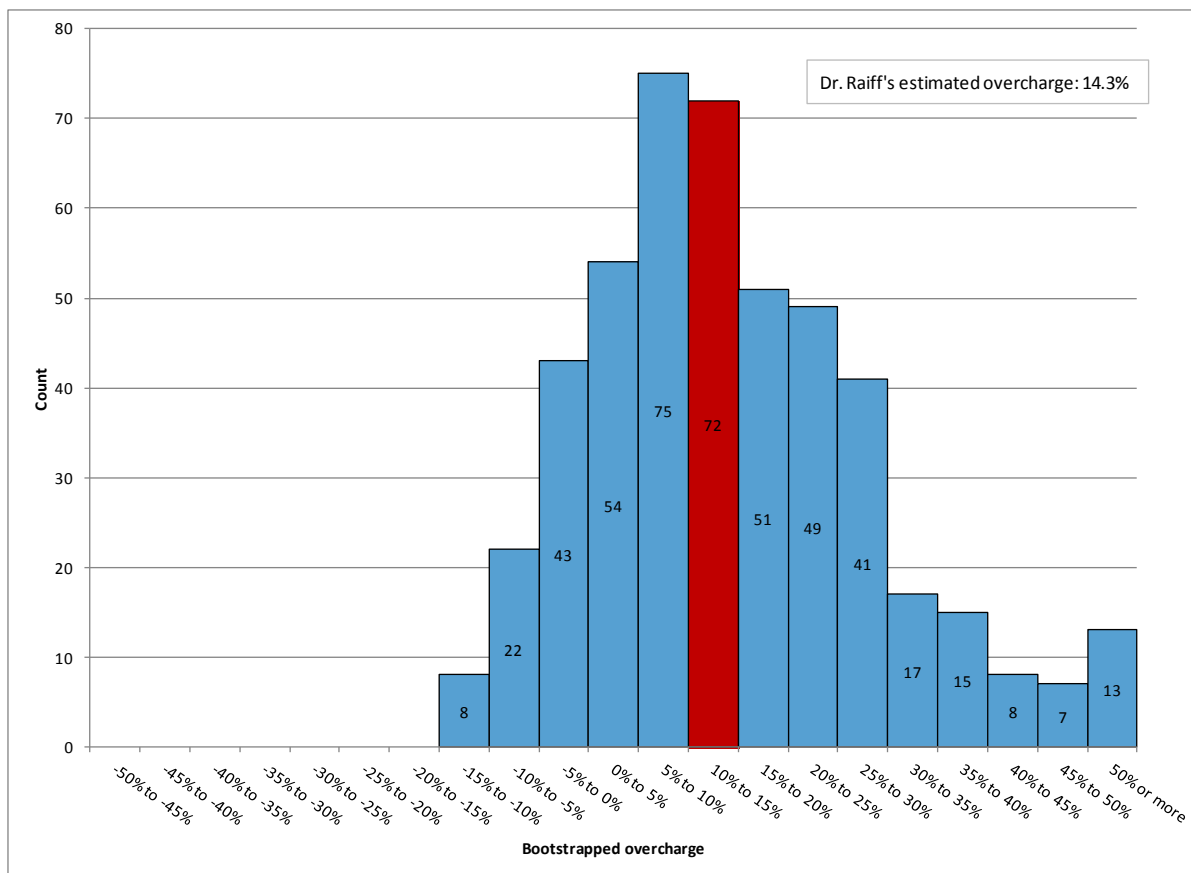
- (86) Figure 1 supports Dr. Raiff's opinion that the conspiracy caused overcharges for TDI purchases because TDI overcharges are always positive.

**Figure 1: Distribution of aggregate overcharges at 95% confidence for benchmark TDI**



- (87) Figure 2 supports Dr. Raiff's opinion that the conspiracy caused overcharges for MDI purchases because in 85% of the instances the bootstrapped overcharges are positive.<sup>87</sup>

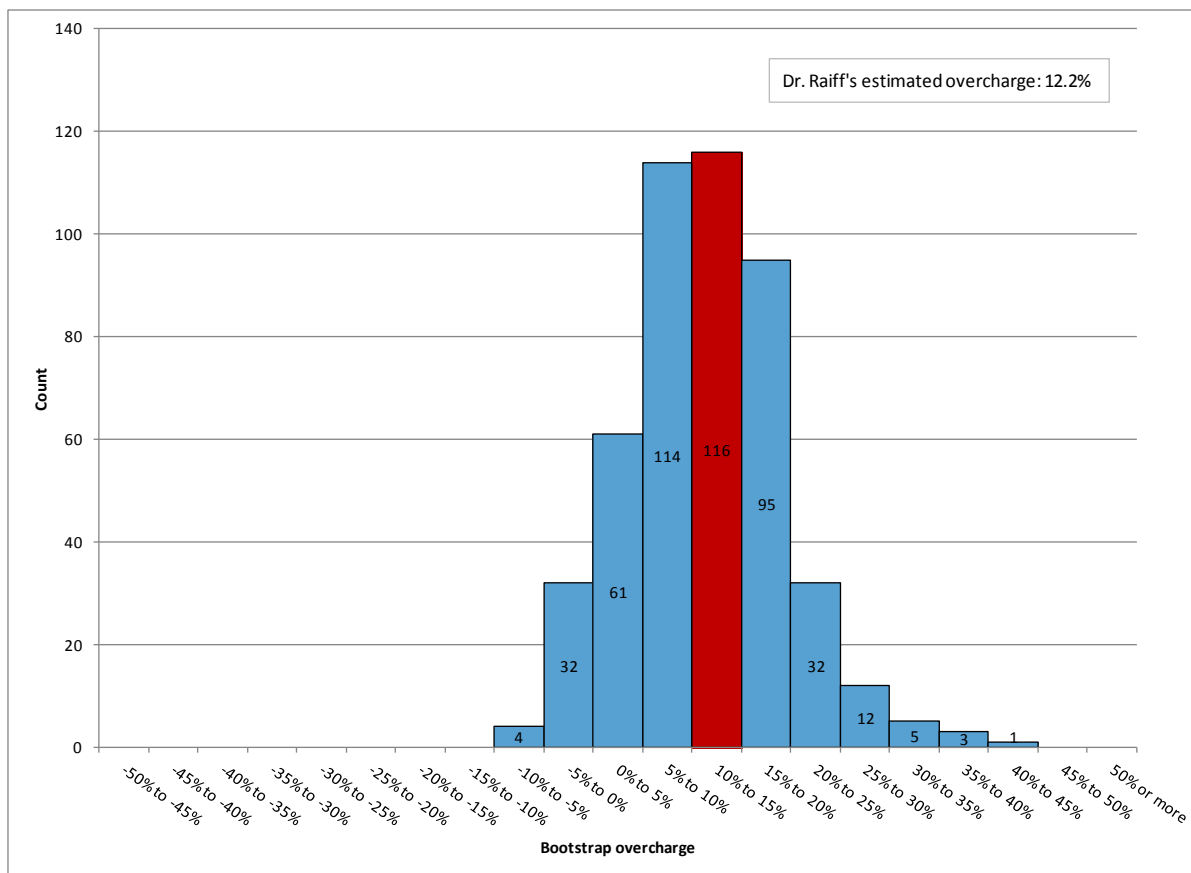
**Figure 2: Distribution of aggregate overcharges at 95% confidence for benchmark MDI**



<sup>87</sup> In 402 out of 475 instances, i.e., 85% of the time, MDI bootstrapped overcharges are positive.

- (88) Figure 3 supports Dr. Raiff's opinion that the conspiracy caused overcharges for polyols purchases because in 92% of the instances the bootstrapped overcharges are positive.<sup>88</sup>

**Figure 3: Distribution of aggregate overcharges at 95% confidence for benchmark polyols**



- (89) In each of Figure 1, Figure 2, and Figure 3, the distribution of overcharges is roughly centered around the aggregate overcharge calculated by Dr. Raiff and most of the distribution is above zero.<sup>89</sup> These results support Dr. Raiff's conclusion that the estimated overcharges reflect the effects of Defendants' anticompetitive conduct—and rebut Dr. Ugone's suggestion to the contrary.

<sup>88</sup> In 439 out of 475 instances, i.e., 92% of the time, polyols bootstrapped overcharges are positive.

<sup>89</sup> The results are similar, and hence my conclusions are the same, when considering class period overcharges. These results are contained in my backup materials.

### **VII.N.3. Dr. Ugone wrongly claims that Dr. Raiff's model yields overcharges that are contrary to Direct Action Plaintiffs' allegations (Reply Report section 3.8.3)**

- (90) Dr. Ugone claimed that Dr. Raiff's models produce nonsensical results because they predict overcharges during the conspiracy period that are smaller than some prediction errors outside the conspiracy.<sup>90</sup> Dr. Raiff illustrated why Dr. Ugone's claim is wrong (Reply Report para. 122). Furthermore, Figure 11 of the Reply Report shows that the benchmark models' average prediction errors over the benchmark period are -0.3% for the benchmark TDI model, 0.6% for the benchmark polyols model, and -0.7% for the benchmark MDI model. Dr. Raiff concluded (Reply Report para. 124) that the small magnitude of these errors confirms a close fit between predicted and actual prices during the benchmark period, and implies that the models account for supply and demand factors. Based upon my review, experience, and training, I agree with Dr. Raiff's conclusion.
- (91) Dr. Ugone also asserted that Dr. Raiff's model is unreliable because it produces negative overcharges over certain portions of the conspiracy period.<sup>91</sup> Paragraphs 125–127 of the Reply Report explain that the patterns of overcharges predicted by Dr. Raiff's model are consistent with a conspiracy whose effectiveness was lower at the start and end of the conspiracy period than in intervening years, varied during the conspiracy period, and was relatively low in late 2001/early 2002. Based upon my review, experience, and training, Dr. Raiff's conclusion that the patterns of overcharges are reasonable and do not indicate that his model is unreliable is reasonable, supported by the record, and consistent with well-accepted econometric practices.
- (92) I also note that Dr. Raiff made a reasonable and conservative decision to include both positive and negative overcharges in the fourth quarter of 2003, after the but-for price lines rose above the actual price lines. The net effect is to reduce estimated overcharges by over \$2 million.<sup>92</sup>

### **VII.O. Dr. Raiff's overcharges are plausible and sustainable (Reply Report section 3.9)**

- (93) Dr. Ugone asserted that Dr. Raiff failed to establish that his predicted but-for prices were sustainable given the implied changes in product-level profitability.<sup>93</sup> Dr. Ugone explained that over a period of years, "competitive market forces and pressures will tend to exist for prices to increase to the point where companies are at least breaking even on those products from an economic perspective."<sup>94</sup> Dr.

---

<sup>90</sup> Ugone Report at para. 4(g).

<sup>91</sup> Ugone Report at para. 147.

<sup>92</sup> Specifically, \$912,618.13 is added to overcharges and \$3,029,946.37 is removed, for a net reduction in overcharges of \$2,117,328.24.

<sup>93</sup> Ugone Report at paras. 85–105.

<sup>94</sup> Ugone Report at para. 88 (emphasis in original).

Ugone further explained that Dr. Raiff's predicted but-for prices would have resulted in financial losses that would have caused Defendants to possibly decrease production or close down plants, and to have been unwilling "in the long run" to supply urethane chemicals at the predicted but-for prices.<sup>95</sup>

- (94) Dr. Raiff concluded that Dr. Ugone's analysis was unreliable (Reply Report para. 132), and that a correct analysis indicated that Defendants would not have substantially decreased production or closed down plants in response to lower predicted but-for prices (Reply Report para. 137). As I now explain, based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.

#### **VII.O.1. Dr. Ugone's opinion is predicated on the wrong measure of profitability (Reply Report section 3.9.1)**

- (95) I agree with Dr. Raiff (and, apparently, Dr. Ugone<sup>96</sup>) that companies find it profitable to continue operating in the short run if their sales revenues cover their variable costs (Reply Report para. 130). Doing so generates incremental revenue which can be used to defray fixed costs, and which would not be available if the company stopped producing. Accordingly, while fixed costs are a factor in a company's long-run decision to permanently shut down a plant, they do not affect a company's short run decision-making.
- (96) Paragraphs 131–132 of the Reply Report explain that Dr. Ugone relied upon the EBIT measure of profitability which includes not only variable costs but also allocated fixed costs. As a result, Dr. Ugone effectively performed a long-run analysis rather than a short-run analysis. Because EBIT includes fixed costs as well as variable costs, it overstates a company's threshold for shutting down in the short run. Based upon my review, experience, and training, and as explained further below, I agree with Dr. Raiff's conclusion that "the Defendants' decisions and actions during this time period make it obvious that Dr. Ugone's long run [sic] analysis is inappropriate and inconsistent with how they actually make their production decisions. His analysis is therefore unhelpful and unreliable for the task at hand."<sup>97</sup>

---

<sup>95</sup> Ugone Dep. at 781:2–782:8.

<sup>96</sup> Ugone Dep. at 271:20–23.

<sup>97</sup> Reply Report at para. 132.

### **VII.O.2. A more appropriate measure shows that Dr. Ugone's opinion is wrong (Reply Report section 3.9.2)**

- (97) Based upon my review, experience, and training, I agree with Dr. Raiff's conclusion that contribution margin—i.e., the amount by which revenues exceed variable costs—is a more appropriate measure than EBIT (Reply Report para. 133).
- (98) Paragraphs 134–135 of the Reply Report explain that, based on Dr. Ugone's own calculations (reported on Figure 12 of the Reply Report), BASF would have had positive contribution margins at predicted but-for prices for TDI, MDI, and polyols every year from 1996 through 2003. Paragraph 136 of the Reply Report explains that Dow's product-line financial statements for TDI, MDI, and polyols do not report contribution margin but do report a reasonable proxy, "trade standard cost"; and that trade standard cost, evaluated at predicted but-for prices, is positive for TDI, MDI, and polyols every year from 1996 through 2003 with the sole exception of TDI in 1998 (in which trade standard cost is negative \$900,000). Reply Report Figure 13. Based upon my review, experience, and training, I agree with Dr. Raiff that these results strongly suggest that, at lower but-for prices, neither BASF nor Dow would have shut down or reduced the supply of MDI, TDI, or polyols (Reply Report para. 137).

### **VII.O.3. Dr. Ugone's assertions are contradicted by his own analysis and are inconsistent with industry facts (Reply Report section 3.9.3)**

- (99) Dr. Raiff concluded that Dr. Ugone's assertions that lower but-for prices possibly would have caused Defendants to decrease production, close down plants, or otherwise been unwilling to supply at but-for prices are contradicted by Defendants' business decisions. Paragraphs 138–143 of the Reply Report explain:
- Dow continued to produce TDI and in fact expanded production despite (according to Dr. Ugone's own calculations) negative EBIT for nine successive years 1998–2006 (para. 139 and Figure 14).
  - Dow's actual cumulative EBIT loss of \$216 million during 1998 through 2003 was only \$47 million (18%) less than it would have been at predicted but-for prices (para. 140).
  - Dr. Ugone failed to explain why the relatively small incremental loss at but-for prices would have caused Dow to change its production decisions (para. 140).
  - Dow did not exit the industry despite losing \$99 million in its TDI business in 2004–2005 and more than \$146 million in its MDI business during 2004–2007 (paras. 140–141).
  - Dr. Ugone failed to explain why Dow would not have been willing to sustain losses in its profitable polyols business as Dow did in its TDI and MDI businesses (para. 142).

Based upon my review, experience, and training, Dr. Raiff's conclusion is reasonable, supported by the record, and consistent with well-accepted econometric practices.

#### **VII.O.4. Dr. Ugone's profitability analysis ignores the overlap between polyether polyol products and other products (Reply Report section 3.9.4)**

- (100) Dr. Raiff concluded that Dr. Ugone erred by focusing solely on the financial results for Defendants' polyether polyol products and ignoring the manner in which these products were integrated into Defendants' businesses. Paragraph 144 of the Reply Report explains that Dr. Ugone did not consider that Dow's strategy in the urethanes market was to maximize the return on its propylene oxide ("PO") business,<sup>98</sup> or that BASF's "verbund" philosophy called for an integrated business strategy. Paragraph 145 of the Reply Report explains that, by focusing on polyether polyol products in isolation, Dr. Ugone ignored important financial ramifications of joint production. For example, reducing polyols production affected Dow's PO, MDI, and TDI businesses, and reducing TDI or MDI production affected Dow's polyols business due to complementarity. Based upon my review, experience, and training, I agree with Dr. Raiff's conclusion that Dr. Ugone erred in failing to consider these factors.

#### **VII.O.5. Contrary to Dr. Ugone's claim, the pattern of Dr. Raiff's overcharges is reasonable (Reply Report section 3.9.5)**

- (101) Dr. Ugone criticized Dr. Raiff's overcharge estimates on the ground that they vary widely over time, do not move in a consistent pattern across all three benchmark products, and in some months are high for some benchmark products and not others.<sup>99</sup> Paragraphs 147–152 of the Reply Report explain:
- Average overcharges are similar across TDI (12.3%), MDI (13.0%), and polyols (10.0%) (para. 147).
  - The effectiveness of conspiracies is frequently lower at the outset and typically varies over time and across products (paras. 148–151).
  - Dr. Raiff's estimated overcharges generally had a positive relationship with one another over time (para. 152 and Figures 15–17).

Based upon my review, experience, and training, Dr. Raiff's conclusion that his estimated overcharges exhibit reasonable patterns is reasonable, supported by the record, and consistent with well-accepted econometric practices.

<sup>98</sup> Propylene is a key feedstock in the production of polyols. See Raiff Report paras. 114–115.

<sup>99</sup> Ugone Report at paras. 141–155.

## **VII.P. Dr. Ugone's remaining criticisms do not change Dr. Raiff's opinions (Reply Report section 4)**

### **VII.P.1. Dr. Ugone's dummy variable models are unreliable (Reply Report section 4.2)**

- (102) Dr. Ugone estimated overcharges using variations of Dr. Raiff's model that incorporate dummy variables, and he asserted that his results show that Dr. Raiff's models are not robust.<sup>100</sup> Paragraphs 155–159 of the Reply Report explain that in this case the predictive models employed by Dr. Raiff are more reliable than Dr. Ugone's dummy variable models because dummy variable models require more stringent assumptions (paras.155–157), dummy variable models understate the effect of a conspiracy on price if the assumptions are not met (para. 158), and the differences in results found by Dr. Ugone are due to the key assumptions being false (para. 159). Dr. Raiff concluded that Dr. Ugone's dummy variable models are unreliable (para. 159).
- (103) Dr. Ugone offers four variants on a dummy variable model. He offers models with either one or two dummies and with either the same explanatory variables as Dr. Raiff or a different set of explanatory variables. Dr. Ugone's models differ significantly from Dr. Raiff's with respect to their average overcharges.
- (104) The models that use the same explanatory variables as Dr. Raiff are clearly less reliable than the predictive models employed by Dr. Raiff because Dr. Raiff's predictive models perform well, produce sensible results, and are the same as a dummy variable approach that has a dummy for each month in the conspiracy period. Thus, in this case Dr. Raiff's predictive modeling approach is more flexible and less restrictive than Dr. Ugone's dummy variable approach and so more reliable. In addition, Dr. Ugone's benchmark MDI model fails to produce sensible results because the but-for price is significantly above the actual price.<sup>101</sup>
- (105) The models that Dr. Ugone offers that use a different set of explanatory variables than Dr. Raiff's are unreliable because they do not account for key cost and demand factors.<sup>102</sup> In addition, Dr. Ugone's benchmark MDI model fails to produce sensible results because the but-for price is significantly above the actual price.<sup>103</sup> Based upon my review, experience, and training, Dr. Raiff's conclusion that Dr. Ugone's dummy variable models are unreliable is reasonable, supported by the record, and consistent with well-accepted econometric practices.

<sup>100</sup> Ugone Report at paras. 180, 185–194.

<sup>101</sup> Ugone Report at ex. 64 at 1; Ugone Report at ex. 65 at 1.

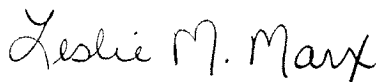
<sup>102</sup> Dr. Ugone's dummy variable models that use a different set of explanatory variables than Dr. Raiff's for PMDI contain no demand factors, for TDI do not contain the key cost factor of toluene prior to 2005, and for CFS polyols do not contain demand factors prior to 2005. Ugone Report at ex. 66 at 8–10; Ugone Report at ex. 67 at 8–10.

<sup>103</sup> Ugone Report at ex. 66 at 1; Ugone Report at ex. 67 at 1.



**VII.P.2. Dr. Raiff has no reason to revise the Defendants' data that he relied upon (Reply Report section 4.3)**

- (106) Dr. Ugone asserted that in three instances Dr. Raiff should not have relied on prices reported in Defendants' sales data.<sup>104</sup> Paragraph 161 of the Reply Report explains that Dr. Raiff and his team performed a substantial amount of work to ensure that Defendant-supplied sales data accurately reflected the prices paid by Plaintiffs, and that Dr. Raiff relied upon Defendants' representations that their data were as complete as possible. Paragraphs 162–165 of the Reply Report explain that Dr. Ugone's concerns are not supported by the documentary evidence and Dr. Raiff reasonably relied upon Defendant-supplied data. Based upon my review, experience, and training, Dr. Raiff's conclusions are reasonable, supported by the record, and consistent with well-accepted econometric practices.
- (107) Dr. Ugone also asserted that Dr. Raiff erroneously estimated damages for certain sales that, according to Defendants' data, were shipped to Plaintiffs but billed to a Defendant or a Canadian affiliate of the Defendant supplying the product.<sup>105</sup> Paragraph 166 of the Reply Report explains that Dr. Raiff was instructed by counsel to do this. My understanding is that Plaintiffs will present proof that they in fact made the purchases in question. Paragraph 167 and Figure 18 of the Reply Report provide adjusted damage calculations (fixing a mistake by Dr. Ugone) should the Court determine that Plaintiffs are not entitled to recover damages on these purchases. Based upon my review, experience, and training, I agree that Dr. Raiff accurately calculates the damages that remain if the challenged purchases are excluded from Plaintiffs' damage claims.




---

Leslie M. Marx

---

September 20, 2013

Date

---

<sup>104</sup> Ugone Report at paras. 202–208.

<sup>105</sup> Ugone Report at paras. 200–201.

## Appendix A. Additional figures

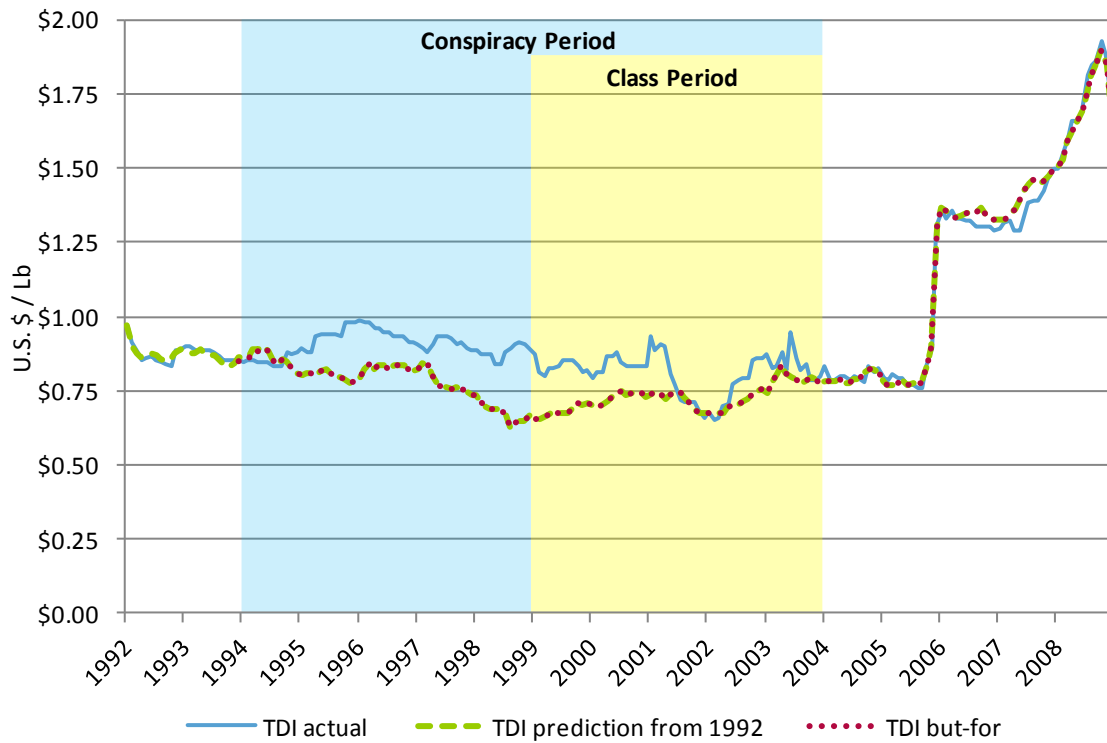
**Figure 4: Benchmark product models**

Variable	TDI	Polyols	MDI
Lag of log(Median TDI)	X	X	
Lag of log(Median Polyol)	X	X	
Lag of log(Median PMDI)			X
Lag of log(Toluene)	X		
Lag of log(Propylene)		X	
Lag of log(Benzene)			X
Lag of log(Natural Gas)	X		X
Lag of log(CFIPI)	X	X	
Lag of log(ACFIPI)			X
Lag of log(Motor Vehicle Assemblies)	X	X	
Lag of log(House Starts)			X
Monthly dummy variables spanning 9/2005 to 1/2006	X	X	X
Post-2005 dummy variable	X	X	-
Change in lag of log(Toluene)	-		
Change in lag of log(Propylene)		+	
Change in lag of log(Benzene)			-
Change in lag of log(Natural Gas)	-	-	-
Change in lag of log(Ammonia)	+		+
Change in lag of log(Chlorine)	-		-
Change in lag of log(Ethylene)		-	
Change in lag of log(Methanol)			-
Change in lag of log(CFIPI)	-	+	
Change in lag of log(ACFIPI)			-
Change in lag of log(Motor Vehicle Assemblies)	-	-	
Change in lag of log(House Starts)			-
Change in lag of log(Wage)	-	-	+
Change in lag of log(Canada / U.S. Foreign Exchange Rate)	+	-	+
Change in lag of log(U.S. / Euro Foreign Exchange Rate)	+	-	-
Change in lag of log(10-Year Treasury Constant Maturity Rate)	-	-	-

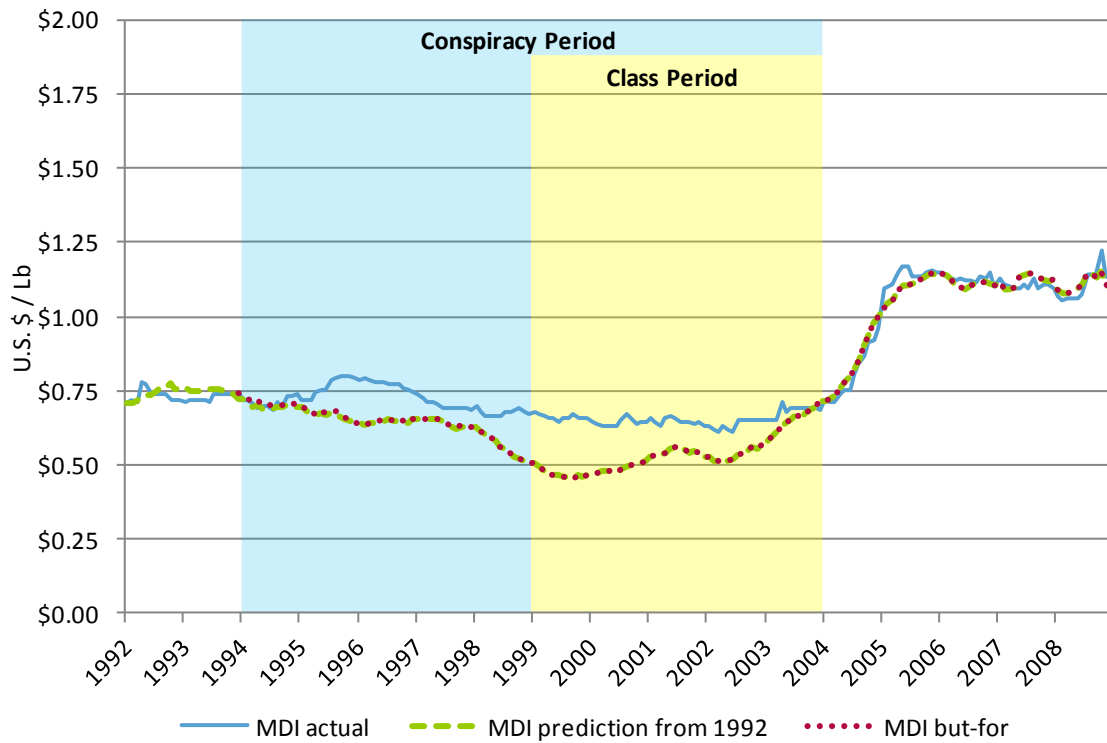
Variable	TDI	Polyols	MDI
Lag of log(Toluene) after 2005; 0 otherwise	-		
Lag of log(Propylene) after 2005; 0 otherwise		+	
Lag of log(Benzene) after 2005; 0 otherwise			-
Lag of log(Natural Gas) after 2005; 0 otherwise	-		-
Lag of log(CFIPI) after 2005; 0 otherwise	+	-	
Lag of log(ACFIPI) after 2005; 0 otherwise			-
Lag of log(Motor Vehicle Assemblies) after 2005; 0 otherwise	+	-	
Lag of log(House Starts) after 2005; 0 otherwise			-
Lag of log(Median TDI) after 2005; 0 otherwise	+	+	
Lag of log(Median Polyols) after 2005; 0 otherwise	-	-	
Lag of log(Median PMDI) after 2005; 0 otherwise			+
R-squared	0.99736	0.99365	0.98749
AIC	-5.47283	-4.66947	-4.01549
Residual autocorrelation	-0.09010	-0.17033	-0.12710
Number of observations	82	82	82

X denotes mandatory variables, + denotes selected optional variables, and - denotes non-selected optional variables.

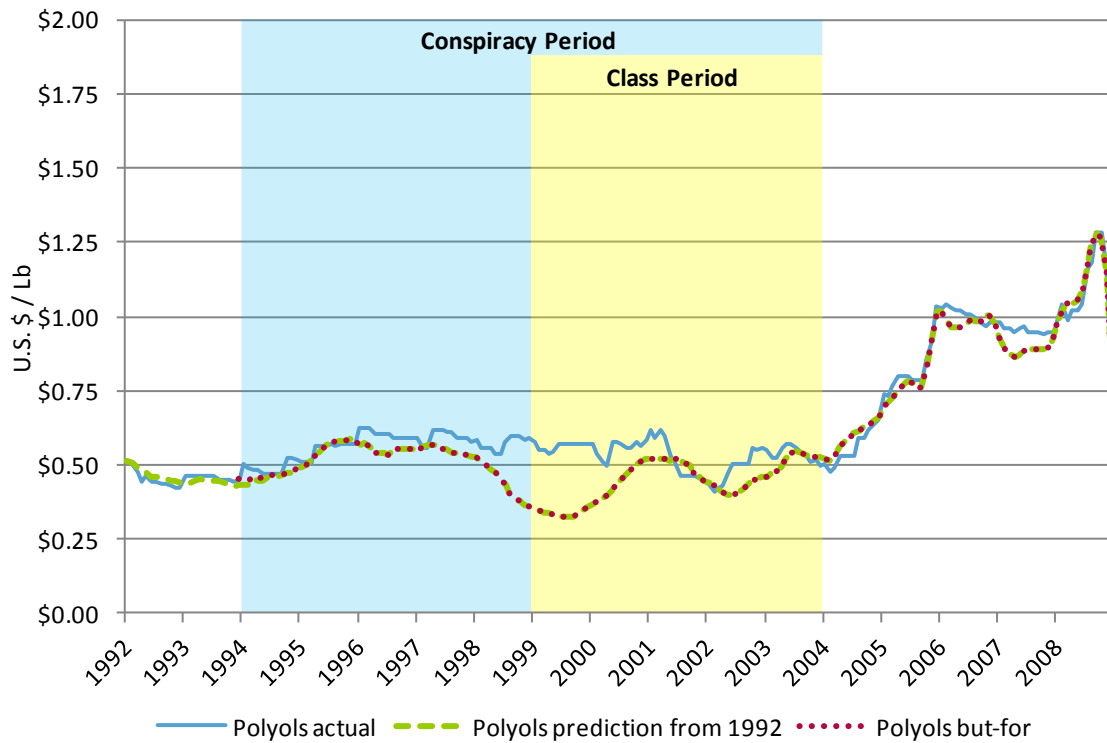
Source: Raiff Report back-up materials

**Figure 5: Actual and predicted prices for TDI 80/20**

Source: Raiff Report Figure 60 and Reply Report back-up materials

**Figure 6: Actual and predicted prices for polymeric MDI**

Source: Raiff Report Figure 61 and Reply Report back-up materials

**Figure 7: Actual and predicted prices for CFS polyols**

Source: Raiff Report Figure 62 and Reply Report back-up materials

## Appendix B. Curriculum vitae

### B.1. Summary of experience

Leslie M. Marx is the Robert A. Bandeen Professor of Economics at the Fuqua School of Business at Duke University. She is an expert in auctions, vertical contracting, antitrust liability, and cartels. Dr. Marx is well known for her innovative ideas in the areas of industrial organization, applied game theory, auctions, procurements, and collusion. She served as Chief Economist of the Federal Communications Commission from August 2005 through August 2006.

Dr. Marx has published extensively in peer-reviewed journals and elsewhere on topics related to industrial organization, applied game theory, auctions, procurements, and collusion. Her published work includes papers on collusive mechanisms, incentives in procurement contracting, slotting allowances, and exclusive dealing.

### B.2. Areas of expertise

- Antitrust damages
- Antitrust liability
- Auctions
- Collusion
- Game theory
- Industrial organization
- Procurements

### B.3. Testimony

My sworn testimony over the last five years is as follows:

- *In re TFT-LCD (Flat Panel) Antitrust Litig.*, No. M:07-1827 (N.D. Cal.). Expert reports and deposition testimony: 2011–2013.
- *In re Elec. Carbon Prod. Antitrust Litig.*, No. 05-6042 (D.N.J.). Expert report: 2009.

## B.4. Education

- Ph.D., Economics, Northwestern University
- M.A., Economics, Northwestern University
- B.S., Mathematics, Duke University

## B.5. Professional experience

- Fuqua School of Business and Department of Economics, Duke University, Robert A. Bandeen Professor of Economics, 2013–present
- Fuqua School of Business and Department of Economics, Duke University, William and Sue Gross Research Fellow and Professor of Economics, 2012–2013
- Fuqua School of Business and Department of Economics, Duke University, Professor of Economics, 2008–2013
- Associate Professor of Economics, Fuqua School of Business, Duke University, 2002–2008
- Chief Economist, U.S. Federal Communications Commission, August 2005–August 2006
- Associate Professor of Economics and Management, W.E. Simon Graduate School of Business Administration, University of Rochester, 2000–2002
- Visiting Associate in Economics, California Institute of Technology, January 2000–June 2000
- Associate Professor of Economics and Management, W.E. Simon Graduate School of Business Administration, University of Rochester, 1999–2000
- Assistant Professor of Economics and Management, W.E. Simon Graduate School of Business Administration, University of Rochester, 1994–1999

## B.6. Editorial boards

- *American Economic Journal: Microeconomics*, Editorial Board, 2007 to present
- *International Journal of Game Theory*, 2009 to present
- Referee: *American Economic Review*, *Econometrica*, *Games and Economic Behavior*, *International Journal of Industrial Organization*, *Journal of Economic Theory*, *RAND Journal of Economics*, *Review of Economic Studies*, *Review of Industrial Organization*
- *Journal of Economic Literature*, Editorial Board, 2010–2012
- *Games and Economic Behavior*, Advisory Editor, 2010–2012



- *International Economic Review*, Associate Editor, 2002–2005

## B.7. Publications

### B.7.a. Research papers in academic journals

- “Plus Factors and Agreement in Antitrust Law.” With William E. Kovacic, Robert C. Marshall, and Halbert L. White. *Michigan Law Review* 110, no. 3 (2011): 393–436.
  - Winner of the 10th Annual Jerry S. Cohen Memorial Fund Writing Award for the best antitrust piece during the prior year.
- “Bidder Collusion at First-Price Auctions.” With Giuseppe Lopomo and Peng Sun. *Review of Economic Design* 15, no. 3 (2011): 177–211.
- “Carbon Allowance Auction Design: An Assessment of Options for the U.S.” With Giuseppe Lopomo, David McAdams, and Brian Murray. *Review of Environmental Economics and Policy* 5, no. 1 (2011): 25–43.
- “Coordinated Effects in the 2010 *Horizontal Merger Guidelines*.” With Wayne-Roy Gayle, Robert C. Marshall, and Jean-Francois Richard. *Review of Industrial Organization* 39, no. 1 (2011): 39–56.
- “The Economics of Contingent Re-Auctions.” With Sandro Brusco and Giuseppe Lopomo. *American Economic Journal: Microeconomics* 3, no. 2 (2011): 165–93.
- “Break-Up Fees and Bargaining Power in Sequential Contracting.” With Greg Shaffer. *International Journal of Industrial Organization* 28, no. 5 (2010): 451–63.
- “Slotting Allowances and Scarce Shelf Space.” With Greg Shaffer. *Journal of Economics & Management Strategy* 19, no. 3 (2010): 575–603.
- “Cartels as Two-Stage Mechanisms: Implications for the Analysis of Dominant-Firm Conduct.” With Randall D. Heeb, William E. Kovacic, and Robert C. Marshall. *Chicago Journal of International Law* 10, no. 1 (2009): 213–31.
- “Individual Accountability in Teams.” With Francesco Squintani. *Journal of Economic Behavior & Organization* 72, no. 1 (2009): 260–73.
- “Quantitative Analysis of Coordinated Effects.” With William E. Kovacic, Robert C. Marshall, and Steven P. Schulenberg. *Antitrust Law Journal* 76, no. 2 (2009): 397–430.
- “The ‘Google Effect’ in the FCC’s 700 MHz Auction.” With Sandro Brusco and Giuseppe Lopomo. *Information Economics and Policy* 21, no. 2 (2009): 101–14.
- “The Vulnerability of Auctions to Bidder Collusion.” With Robert C. Marshall. *Quarterly Journal of Economics* 124, no. 2 (2009): 883–910.

- “Cartel Price Announcements: The Vitamins Industry.” With Robert C. Marshall and Matthew E. Raiff. *International Journal of Industrial Organization* 26, no. 3 (2008): 762–802.
  - Awarded the 2009 Paul Geroski Best Article Prize for one of the best two articles published in the *International Journal of Industrial Organization* in 2008.
- “Bidder Collusion.” With Robert C. Marshall. *Journal of Economic Theory* 133, no. 1 (2007): 374–402.
- “Exploring Relations Between Decision Analysis and Game Theory.” With Jules van Binsbergen. *Decision Analysis* 4, no. 1 (2007): 32–40.
- “Rent Shifting and the Order of Negotiations.” With Greg Shaffer. *International Journal of Industrial Organization* 25, no. 5 (2007): 1109–25.
- “Upfront Payments and Exclusion in Downstream Markets.” With Greg Shaffer. *RAND Journal of Economics* 38, no. 3 (2007): 823–43.
- “Economics at the Federal Communications Commission.” *Review of Industrial Organization* 29, no. 4 (2006): 349–68.
- “Inefficiency of Collusion at English Auctions.” With Giuseppe Lopomo and Robert C. Marshall. *B.E. Journal of Theoretical Economics* 5, no. 1 (2005).
- “Opportunism and Menus of Two-Part Tariffs.” With Greg Shaffer. *International Journal of Industrial Organization* 22, no. 10 (2004): 1399–1414.
- “Opportunism in Multilateral Vertical Contracting: Nondiscrimination, Exclusivity, and Uniformity: Comment.” With Greg Shaffer. *American Economic Review* 94, no. 3 (2004): 796–801.
- “The Joint Determination of Leverage and Maturity.” With Michael J. Barclay and Clifford W. Smith, Jr. *Journal of Corporate Finance* 9, no. 2 (2003): 149–67.
  - Winner, Outstanding Paper in Corporate Finance, 1997 Southern Finance Association Meetings.
- “Adverse Specialization.” With Glenn M. MacDonald. *Journal of Political Economy* 109, no. 4 (2001): 864–99.
- “Insurer Ownership Structure and Executive Compensation as Complements.” With David Mayers and Clifford W. Smith, Jr. *Journal of Risk and Insurance* 68, no. 3 (2001): 449–63.
  - Winner, Outstanding Paper in Financial Services, 1998 Southern Finance Association Meetings.
- “Dynamic Voluntary Contribution to a Public Project.” With Steven A. Matthews. *Review of Economic Studies* 67, no. 2 (2000): 327–58.

- “Order Independence for Iterated Weak Dominance.” *Games and Economic Behavior* 31, no. 2 (2000): 324–29.
- “Adaptive Learning and Iterated Weak Dominance.” *Games and Economic Behavior* 26, no. 2 (1999): 253–78.
- “Odd-Eighth Avoidance as a Defense Against SOES Bandits.” With Eugene Kandel. *Journal of Financial Economics* 51, no. 1 (1999): 85–102.
- “Payments for Order Flow on NASDAQ.” With Eugene Kandel. *Journal of Finance* 54, no. 1 (1999): 35–66.
- “Predatory Accommodation: Below-Cost Pricing Without Exclusion in Intermediate Goods Markets.” With Greg Shaffer. *RAND Journal of Economics* 30, no. 1 (1999): 22–43.
- “Process Variation as a Determinant of Bank Performance: Evidence from the Retail Banking Study.” With Frances Frei, Ravi Kalakota, and Andrew Leone. *Management Science* 45, no. 9 (1999): 1210–20.
- “Efficient Venture Capital Financing Combining Debt and Equity.” *Review of Economic Design* 3, no. 4 (1998): 371–87.
- Winner, Koç University Prize for the Best Paper of the Year in *Review of Economic Design*.
- “The Effects of Transaction Costs on Stock Prices and Trading Volume.” With Michael J. Barclay and Eugene Kandel. *Journal of Financial Intermediation* 7, no. 2 (1998): 130–50.
- “Cost Effective Use of Muscle Relaxants: A Decision Analysis.” With Jeffrey S. Rubenstein, Wendy Colin, Darryl Jackson, Craig Lockwood, and Janice Molloy. *Pediatrics* 100, no. 3 (1997): 451–52.
- “NASDAQ Market Structure and Spread Patterns.” With Eugene Kandel. *Journal of Financial Economics* 45, no. 1 (1997): 35–60.
- “Order Independence for Iterated Weak Dominance.” With Jeroen M. Swinkels. *Games and Economic Behavior* 18, no. 2 (1997): 219–45.

#### **B.7.b. Research papers published in books and conference volumes**

- “Economics and the Efficient Allocation of Spectrum Licenses.” With Simon Loertscher. In *Mechanisms and Games for Dynamic Spectrum Access*, eds. Tansu Alpcan, Holger Boche, Michael L. Honig, and H. Vincent Poor. Cambridge University Press, forthcoming.
- “Tacit Collusion in Oligopoly.” With Edward Green and Robert C. Marshall. In *Oxford Handbook of International Antitrust Economics*, eds. Roger D. Blair and D. Daniel Sokol. Oxford University Press, forthcoming.

- “The Economics of Auctions and Bidder Collusion.” With Robert C. Marshall and Michael J. Meurer. In *Game Theory and Business Applications*, 2nd ed., eds. Kalyan Chatterjee and William F. Samuelson. New York: Kluwer Academic Publishers, forthcoming.
- “Coordinated Effects in Merger Review: Quantifying the Payoffs from Collusion.” With William E. Kovacic, Robert C. Marshall, and Steven P. Schulenberg. In *Annual Proceedings of the Fordham Competition Law Institute: International Antitrust Law & Policy*, ed. Barry E. Hawk, 271–85. Huntington, NY: Juris Publishing, Inc., 2007.
- “Lessons for Competition Policy from the Vitamins Cartel.” With William E. Kovacic, Robert C. Marshall, and Matthew E. Raiff. In *The Political Economy of Antitrust*, vol. 282, eds. Vivek Ghosal and Johan Stennek, 149–76. New York: Elsevier, 2007.
- “Bidding Rings and the Design of Anti-Collusion Measures for Auctions and Procurements.” With William E. Kovacic, Robert C. Marshall, and Matthew E. Raiff. In *Handbook of Procurement*, eds. Nicola Dimitri, Gustavo Piga, and Giancarlo Spagnolo, 381–411. Cambridge University Press, 2006.

### **B.7.c. Books**

- *The Economics of Collusion: Cartels and Bidding Rings*. With Robert C. Marshall. Cambridge: MIT Press, 2012.

### **B.7.d. Work in progress**

- “A Long Way Coming: Designing Centralized Markets with Privately Informed Buyers and Sellers.” With Simon Loertscher and Tom Wilkening, 2013.
- “Antitrust Leniency with Multi-Product Colluders.” With Robert C. Marshall and Claudio Mezzetti, 2013.
- “Buyer Resistance for Cartel versus Merger.” With Vikram Kumar, Robert C. Marshall, and Lily Samkharadze, 2013.
- “Monopolization Conduct by Cartels.” With Robert C. Marshall and Lily Samkharadze, 2013.
- “Buyer Power, Exclusion, and Inefficient Trade.” With Greg Shaffer, 2007.
- “Opportunism and Nondiscrimination Clauses.” With Greg Shaffer, 2001.

## **B.8. Honors and awards**

- FCC Woman Leader, Minority Media and Telecommunications Council, April 2013
- Top 100 Women in Antitrust, *Global Competition Review*, March 2013
- Business School Professor of the Week, *Financial Times*, July 2012

- Alfred P. Sloan Doctoral Dissertation Fellowship, 1993–1994
- Teaching Honor Roll, Simon School of Business, University of Rochester, 1999, 2001
- National Science Foundation Graduate Fellowship, 1989–1992
- Mary Love Collins Memorial Scholarship, 1989–1990
- Julia Dale Memorial Award in Mathematics, 1989
- Marie James Postgraduate Scholarship, 1989
- Phi Eta Sigma Graduate Scholarship, 1989
- Valedictorian, Duke University, 1989
- Alice M. Baldwin Scholarship, 1988–1989
- Faculty Scholar Award, Duke University, 1988–1989
- Phi Chi Theta Foundation Scholarship, 1988–1989
- Phi Eta Sigma Senior Award, 1988–1989
- Golden Key National Honor Society Scholarship, 1987–1988
- National Merit Scholarship, 1985
- Phi Beta Kappa Scholarship, 1985

## **Appendix C. Additional materials relied upon**

In addition to the materials identified in paragraph (10), I have relied upon the following.

### **C.1. Expert reports, depositions, and case documents**

#### **C.1.a. Expert Reports**

- Expert Report of Dr. James T. McClave, Apr. 15, 2011.
- Revised Expert Report and Backup of Matthew E. Raiff. Ph.D., May 13, 2011.
- Economic Expert Report and Backup of Professor Kenneth G. Elzinga, Mar. 23, 2012.
- Rebuttal Expert Report, Backup, and Exhibits of Keith R. Ugone, Ph.D. Responding to the Expert Report of Dr. Raiff, Mar. 23, 2012.
- Backup for Reply Report of Matthew E. Raiff, PhD, May 25, 2012.
- Revised Reply Report and Backup of Matthew E. Raiff. Ph.D., July 13, 2012.

#### **C.1.b. Depositions**

- Deposition of Lawrence Stern (Bayer), Nov. 2, 2009.
- Deposition of Michelle Blumberg (Bayer), July 21, 2010.
- Deposition of Stephanie Barbour (Dow), Sept. 14–15, 2010.
- Deposition of G. Thomas Harrick (Bayer), Nov. 10, 2010.
- Deposition of Matthew E. Raiff, May 25–26, 2011.
- Deposition of Kenneth G. Elzinga, Apr. 3–4, 2012.
- Deposition of Keith R. Ugone, Apr. 16–18, 2012.
- Deposition of Matthew E. Raiff, June 27, 2012.

#### **C.1.c. Legal filings**

- Complaint, *Carpenter Co. v. BASF SE*, No. 08-2617, Dec. 23, 2008.
- Complaint, *Dash Multi-Corp, Inc. v. BASF SE*, Nov. 3, 2009.
- Complaint, *Woodbridge Foam Corp. v. BASF SE*, Nov. 21, 2008.
- Dow Chemical Co.'s Memorandum in Support of Motion to Exclude the Expert Opinion of Opt-Out Plaintiffs' Damages Expert Dr. Matthew Raiff, Aug. 17, 2012.

- Dow Chemical Company's Reply in Support of Motion to Exclude the Expert Opinion of Opt-Out Plaintiffs' Damages Expert Dr. Raiff, Nov. 6, 2012.
- Direct Action Plaintiffs' Second Collective Amended and Supplemental Responses to Defendants' First Set of Merits Interrogatories, Sept. 8, 2011.
- Direct Action Plaintiffs' Opposition to The Dow Chemical Company's Motion to Exclude the Expert Opinion of Opt-Out Plaintiffs' Damages Expert Dr. Matthew E. Raiff, Oct. 5, 2012.
- Memorandum and Order on Class Certification, July 28, 2008.
- Memorandum and Order on Summary Judgment, Dec. 18, 2012.
- Memorandum and Order on Summary Judgment, Jan. 4, 2013.
- Transcript of Proceedings before Honorable John W. Lungstrum, vols. 1–2, Nov. 19, 2012.
- Memorandum and Order, Document Number 2974, Aug. 13, 2013.

#### **C.1.d. Other documents**

- Dr. Matthew E. Raiff's memorandum on his interview with Phil Proger, Apr. 14, 2011.
- Dr. Matthew E. Raiff's notes of his interview with Phil Proger, Apr. 14, 2011.
- Dr. Matthew E. Raiff's questions for Phil Proger, Apr. 14, 2011.
- Email from Jodi Trulove, Plaintiff's counsel, Dickstein Shapiro LLP, to Philip A. Proger, counsel for Bayer, Jones Day (May 22, 2012).

#### **C.1.e. Interview**

- Interview of Philip Proger, Esq., Sept. 20, 2013 (see memorandum provided with back-up materials).

### **C.2. Academic literature**

- Akaike, Hirotugu. "A New Look at the Statistical Model Identification." *IEEE Transactions on Automatic Control* 19, no. 6 (1974): 716–23.
- Anderson, David Ray, Dennis J. Sweeny, and Thomas A. Williams. *Statistics for Business and Economics*, rev. 10th ed. Mason, OH: Thompson South-Western, 2008.
- Bernheim, B. Douglas, and Michael D. Whinston. "Multimarket Contact and Collusive Behavior." *RAND Journal of Economics* 21, no. 1 (1990): 1–26.
- Bolotova, Yuliya, John M. Connor, and Douglas J. Miller. "The Impact of Collusion on Price Behavior: Empirical Results from Two Recent Cases." *Journal of Industrial Organization* 26, no. 6 (2008): 1290–1307.



- Borenstein, Severin and Andrea Shepard. “Dynamic Pricing in Retail Gasoline Markets.” *RAND Journal of Economics* 27, no. 3 (1996): 429–51.
- Carlton, Dennis W., and Jeffrey M. Perloff. *Modern Industrial Organization*. Rev. 4th ed. Boston: Addison Wesley, 2005.
- Casella, George, and Roger L. Berger. *Statistical Inference*. Belmont, CA: Wadsworth, 1990.
- Connor, John M. “Global Cartels Redux: The Amino Acid Lysine Antitrust Litigation.” In *The Antitrust Revolution*. 4th ed., edited by John E. Kwoka and Lawrence J. White, 300–28. Oxford: Oxford University Press, 2004.
- Connor, John M. “What Can We Learn from the ADM Global Price Conspiracies?” Working paper, Purdue University, 1998.
- Connor, John M., and Robert H. Lande. “How High Do Cartels Raise Prices? Implications for Optimal Cartel Fines.” *Tulane Law Review* 80 (2005): 513–70.
- Efron, Bradley, and Robert Tibshirani. *An Introduction to the Bootstrap*. Vol. 57. Boca Raton, FL: CRC Press, 1993.
- Ellison, Glenn. “Theories of Cartel Stability and the Joint Executive Committee.” *RAND Journal of Economics* 25, no. 1 (1994): 37–57.
- Elzinga, Kenneth G. “New Developments on the Cartel Front.” *Antitrust Bulletin* 29 (1984): 3–26.
- Epstein, Roy J. “An Econometric Primer for Lawyers.” *Antitrust* 25, no.3 (2011): 29–33.
- Froeb, Luke M., Robert A. Koyak, and Gregory J. Werden. “What is the Effect of Bid-Rigging on Prices?” *Economics Letters* 42, no. 4 (1993): 419–23.
- Green, Edward J., and Robert H. Porter. “Noncooperative Collusion under Imperfect Price Information.” *Econometrica* 52, no. 1 (1984): 87–100.
- Greene, William H. *Econometric Analysis*. 7th ed. Upper Saddle River, NJ: Prentice Hall, 2007.
- Grossman, Peter Z. “Why One Cartel Fails and Another Endures.” In *How Cartels Endure and How They Fail*, edited by Peter Z. Grossman, 111–29. Northampton, MA: Edward Elgar Publishing, 2004.
- Haltiwanger, John, and Joseph E. Harrington. “The Impact of Cyclical Demand Movements on Collusive Behavior.” *RAND Journal of Economics* 22, no. 1 (1991): 89–106.
- Harrington, Joseph E. “Behavioral Screening and the Detection of Cartels.” In *European Competition Law Annual 2006: Enforcement of Prohibition of Cartels*, edited by Claus-Dieter Ehlermann and Isabela Atanasiu, 1–17. Portland: Hart Publishing, 2007.
- Harrington, Joseph E. *How Do Cartels Operate?* Hannover, MA: Now Publishers Inc., 2006.



- Harrington, Joseph E., and Joe Chen. “Cartel Pricing Dynamics with Cost Variability and Endogenous Buyer Detection.” *International Journal of Industrial Organization* 24, no. 6 (2006): 1185–1212.
- Kovacic, William E., Robert Marshall, Leslie Marx, and Halbert White. “Plus Factors and Agreement in Antitrust Law.” *Michigan Law Review* 110, no. 3 (2011): 393–436.
- Lanning, Steven G. “Costs of Maintaining a Cartel.” *Journal of Industrial Economics* 36, no. 2 (1987): 157–74.
- Lanzillotti, Robert F. “The Great School Milk Conspiracies of the 1980s.” *Review of Industrial Organization* 11 (1996): 413–58.
- Levenstein, Margaret C., and Valerie Y. Suslow. “International Cartels, in 2.” *Issues in Competition Law and Policy* (2008): 1107–26.
- Levenstein, Margaret C., and Valerie Y. Suslow. “Studies of Cartel Stability: A Comparison of Methodological Approaches.” In *How Cartels Endure and How They Fail*, edited by Peter Z. Grossman, 9–52. Northampton, MA: Edward Elgar Publishing, 2004.
- Levenstein, Margaret C., and Valerie Y. Suslow. “What Determines Cartel Success?” *Journal of Economic Literature* 44 (2006): 43–95.
- Marshall, Robert C., and Leslie M. Marx. *The Economics of Collusion: Cartels and Bidding Rings*. Cambridge, MA: MIT Press, 2012.
- McCrary, Justin, and Daniel L. Rubinfeld. “Measuring Benchmark Damages in Antitrust Litigation.” Working paper, Jan. 2011.
- Peters, Craig. “Evaluating the Performance of Merger Simulation: Evidence from the U.S. Airline Industry.” *Journal of Law and Economics* 49 (2006): 627–49.
- Porter, Robert H., and J. Douglas Zona. “Ohio School Milk Markets: An Analysis of Bidding.” *RAND Journal of Economics* 30 (1999): 263–88.
- Rotemberg, Julio J., and Garth Saloner. “A Supergame Theoretical Model of Price Wars during Booms.” *American Economic Review* 76, no. 3 (1986): 390–407.
- Rubinfeld, Daniel L. “Reference Guide on Multiple Regression.” In *Reference Manual on Scientific Evidence*. 3rd. ed., 303–57. Washington, DC: The National Academies Press, 2011.
- Shibata, Rieta. “Asymptotically Efficient Selection of the Order of the Model for Estimating Parameters of a Linear Process.” *Annals of Statistics* 8, no. 1 (1980): 147–64.
- Stickney, Clyde P., and Weil, Roman L. *Financial Accounting: An Introduction to Concepts, Methods and Uses*. 10th ed. Mason, OH: South-Western College Publishing, 2002.

- Stock, James H., and Mark W. Watson. *Introduction to Econometrics*. 3rd ed. Boston: Addison Wesley, 2011.
- Suslow, Valerie Y. “Cartel Contract Duration: Empirical Evidence from Inter-war International Cartels.” *Industrial and Corporate Change* 14, no. 5 (2005): 705–44.
- Weisberg, Sanford. *Applied Linear Regression*. 3rd ed. Hoboken: John Wiley & Sons, 2005.
- White, Halbert. “Time-Series Estimation of the Effects of Natural Experiments.” *Journal of Econometrics* 135, nos. 1–2 (2006): 527–66.
- Wooldridge, Jeffrey M. *Introductory Econometrics: A Modern Approach*. 4th ed. Mason, OH: South-Western Cengage Learning, 2009.